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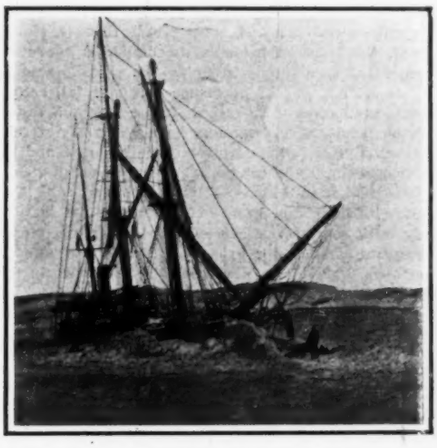
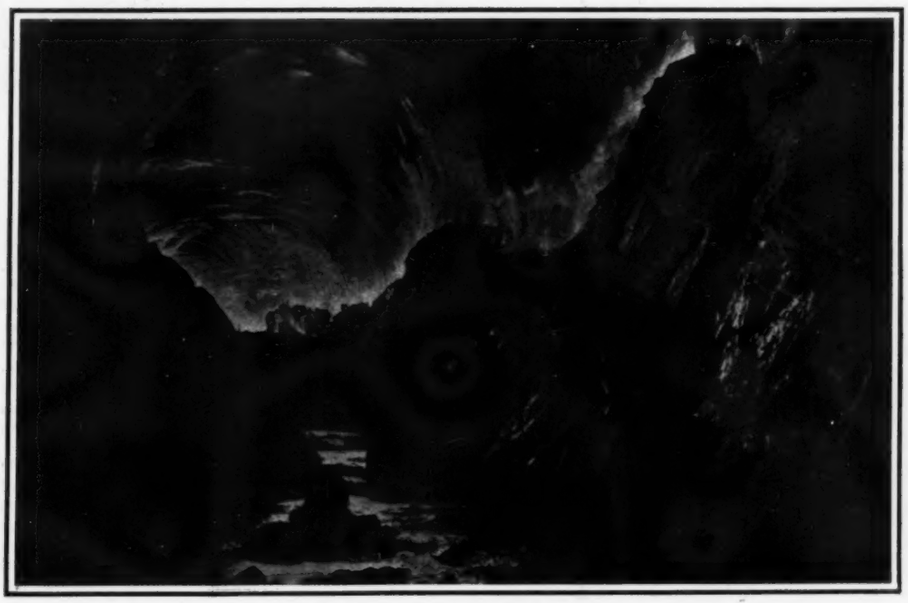
A SCENE IN THE GREAT ICE CAVE.



THE "DANMARK" IN THE ICE.

A GREAT ICE CAVE, 1¼ MILES LONG.



THE TORRENT IN THE GREAT ICE CAVE.

A SCENE IN GREENLAND.

THE DOGS ON GUARD BESIDE THE SHIP.

ERICHSEN'S TRAGIC GREENLAND EXPEDITION.

ERICHSEN'S GREENLAND EXPEDITION.*

THE TRAGEDY OF A SUCCESSFUL EXPLORATION OF GREENLAND.

BY ACHTON FRIIS.

A RETROGRESSION of man toward the brute is within the limit of possibility. When men are suddenly isolated from the world, with a single object in view, the accomplishment of a task requiring great expenditure of energy and brute force, they soon feel that their efficiency will be best promoted by taking good care of their animal natures. Above all, they must have abundant food, and as they appease their ravenous appetites with "Danish preserves," that is, frozen meat, the transformation is accomplished, the development of carnivorous instincts being accelerated by an occasional dish of bear's meat or seal fat, according to the hazard of the chase. If one retains a vestige of the faculty of observation, he may give it exercise by watching the gradual atrophy of the brain and the development of the caudal vertebræ—in other men.

The region in which we lived for two years is as inhospitable as can well be conceived. From the first day until the last we carried on a bitter and almost incessant struggle for existence. Yet in the years to come we shall think with regret of our sojourn in this magnificent desert of rock and sea coast and ice. For us, this country is something more than a new line carefully traced on the map, a new booty thrown to the hungry horde of science. It is a familiar place, where we experienced, together with much suffering and sorrow, the joy of strange sensations, never to be forgotten.

How can we forget the slow, majestic approach of the long winter night, the light fading gradually away while, in our stanch and warm floating home, we prepared for the tasks which were to give us occupation during six months of darkness?

Then the resurrection! The feeble glimmer of light, so long awaited and so ardently wished for, appeared at last. After a few more days—or, rather, revolutions of the hands of the clock—the cry of the snow partridge announced the coming of the dawn, and the sun shone above the southern horizon. Then we went forth, wandering aimlessly, pale, shunning the light like moles, with eyes blinking in the glare of the sun and aching from much writing and figuring by lamplight during that interminable night, with our heavy swollen limbs nipped cruelly by the unaccustomed cold. But the fever of battle soon returned, and we clenched our fists and resolved to triumph over all obstacles.

I still see the brightly-colored rocks sparkling under the low autumn sun; the new, glistening, crystalline ice; the majestic fjords, filled with fallen icebergs of wondrous variety and beauty of coloring; and feel the impressive silence reigning over all and producing a strange buzzing to the ears. Later in the season, when the sun clung to the southern horizon, a vast shadow bounded by an ill-defined circle filled the northern sky, and a pale yellow moon shone weirdly from the midst of its violet gloom.

Then came a sudden change. A dull groaning sound from behind the wall of icebergs announced the coming storm, which quickly swept up the fjord and struck the ship. In the fjord a whirlwind carried aloft great masses of snow, which were augmented by other masses that fell from the cliffs. The glaciers cracked with loud reports, but the crevasses were quickly filled and covered with snow.

During two days no man left the ship, for to venture outside was to court certain and speedy death. At last the storm abated and silence returned. The fjord was completely frozen. Winter had come.

The polar night was preceded by a long, slowly-dying twilight, and as the shadow deepened our nerves gave way. We became morose and irritable as we huddled around the stove and the lamps, with furtive eyes and an ever-increasing hatred toward all mankind.

There was no living thing within thousands of miles. We were alone with our dogs. These brave and faithful servants, though troublesome at times, were more valuable than men. Grouped in black masses around the ship, silent and giving no sign of life except the steam of their breath rising slowly in the moonlight, they watched, that we might sleep. Among themselves they were as quarrelsome as we, and many a fierce battle was fought for the possession of a bone.

Good humor and energy returned with the sun. The sledges were made ready, and provisions were forwarded to the first stopping places of the contemplated expedition. The cold was still intense, the ice thick, and the snow firm, when, on a fine morning in March, the long train of sledges started for the conquest of the North. We who remained behind busied ourselves with provisioning the stopping places for the explorers' return. It was hard work, for all the dogs were gone, and we had to draw the sledges ourselves. My own party returned in a few weeks, weary and sun-burned, after a journey of nearly 200 miles. Soon afterward, the other two provisioning parties returned.

Then we waited. Spring passed, and the large birds that heralded the approach of summer flew northward in noisy flocks. Some of them settled with a deafening uproar on the little islands to our north. In foggy weather they disappeared from view, but we still heard their cries and the flapping of their wings. As the sun rose higher the fjord became magnificent, but one thing made us uneasy. The weather was too warm, and the ice was cracking. One night toward the end of June we were taken by surprise by the arrival of Koch and his two companions. "Good news!" they cried. "Complete success. The extremity of Greenland has been reached, and the whole country explored, surveyed, and charted."

"Good! And the others?"

"They are coming. They will be here in two days at most."

But they never came!

Our anxiety increased hourly as we saw the new ice drifting along the shore, all summer, while to seaward extended a field of solid ice, yards in thickness. Then we began to appreciate the treacherous hostility of Arctic nature. As a relief to our feelings we hunted, but without enthusiasm, and consequently without success—and our poor dogs were pining for fresh meat. It was impossible to go in search of the explorers, for the ice was not strong enough to bear us.

Autumn came, and the birds flew southward. When the new ice was strong enough, a search party of six men started with the famished dogs. In a few weeks they returned in despair. After driving the dogs until they could scarcely stand, their progress was suddenly arrested by open water. Thenceforth we were cut off from all possibility of communicating with our three unfortunate comrades.

We passed a horrible winter, tormented by anxiety concerning the fate of our comrades, and also by the fear that the barrier of ice which shut us out from the world might remain unbroken another year.

Yet we had reason to be proud of the splendid result we had accomplished—the exploration and survey of the entire coast. A few supplementary tasks, and our work would be finished. But we felt that our work would not be finished until we had found our comrades, and that the strongest of us must make a supreme effort to search the coast and learn the truth.

In the spring the party started, and returned much sooner than we expected. They had learned the essential truth, but the details will never be known. Our missing comrades, struggling southward, had fallen one by one, and the last survivor had written in the journal these simple and heroic words: "Vi er dode." ("We are dead.")

In our grief we remembered what we had been taught at home: "You are like soldiers. The work of those who fall must be taken up by those who remain, until the task is accomplished."

We went to work, and at last, after two years' absence, our eyes rested once more on the coast of Denmark.—L'Illustration.

* Mylius Erichsen sailed from Copenhagen, in the "Danmark," June 24, 1906, to survey the almost unknown part of the northeast coast of Greenland, between Koldewey's farthest north, near Cape Bismarck, and Peary's farthest east, near Cape Bridgman, a distance of about 900 miles. After forcing a passage through a belt of ice from 125 to 150 miles wide, the "Danmark" anchored, in August, 1906, near Cape Bismarck and remained there two years. The autumn and early spring were occupied in establishing depots of provisions. Two exploring parties, and two parties commissioned to establish more distant bases of supply, 10 men and 90 dogs in all, started from the ship in March. Erichsen, accompanied by Hagen and the Greenlander Broniund, went westward to find the point established by Peary near Cape Glacier, while Capt. Koch with two companions pushed northward along the coast toward Cape Bridgman.

Three months later Koch's party returned. They had reached Cape Bridgman, and in their return journey had met Erichsen, who had encountered obstacles which made a detour necessary, but was again struggling northward.

Erichsen and his companions never returned. All that is known of their wanderings and their fate is derived from the diary kept by Broniund, which was ultimately recovered. They reached Cape Glacier, but were compelled by the melting of the ice to pass the summer (1907) in Danmark Fjord. In autumn they attempted to proceed by land to a base of supply established on the coast, but were overtaken by the winter night and perished, one after another, of cold and hunger.

In June they reached Cape Glacier, thus proving that Greenland is an island. But their provisions were exhausted, and thenceforth they were dependent on the success of the chase, and their return journey was soon arrested by the softening of the snow and ice. In August the diary notes that game is very scarce and that men and dogs are weakened by starvation. In hunting they were caught on a floe surrounded by water, and compelled to kill some of the dogs to feed the rest and themselves. They escaped from the floe, but the struggle with cold and hunger grew more bitter. On October 19, with their four remaining dogs, they formed the desperate resolve to attempt to cross the ice-clad mountains, where hunting is impossible, to a base of supplies on the coast. It was their only chance.

On October 23 they reached the crest of the mountains, but their shoes were gone, and they suffered horribly. The last brief entry in the diary contains little but the following: "Dead, in the fjord, in November . . . I can go no farther because of my frozen feet and the darkness. The bodies of the others lie in front of the glacier. Hagen died November 15, and Erichsen about ten days later. Jorgen Broniund."

This diary and the records of the expedition, carefully wrapped, were found beside Broniund's body.

In July, 1908, the "Danmark," having accomplished her mission, forced a passage through the ice and sailed homeward. The results accomplished by the expedition have not yet been published in detail, but the establishment of the one fact that Greenland is an island, separated from Pearyland by a wide sound, is sufficient to immortalize the names of Mylius Erichsen and his brave companions.

Achton Friis, the author of the above article, was one of the artists of the Erichsen expedition.

FRENCH ARMY TESTS OF AUTOMOBILES FOR HAULING SUPPLIES.

DURING last year there was carried out a very thorough series of tests of automobiles for transporting army supplies which were held during the last maneuvers of the French army. Capt. Ecochard of the Etat-Major and delegate of the Minister of War has furnished the following note concerning the performance of the heavy-weight cars. A more complete official report on the subject will be published at a later date.

The army maneuvers in France, which presented an exceptional importance this year, were utilized in order to continue the experiments upon the use of heavy hauling cars and automobile trains for transporting the army supplies, and these trials brought out many points in favor of automobiles for this purpose. The two corps of the Eastern Army were supplied exclusively by automobiles from the 9th to the 18th of September. To assure this service the Etat-Major disposed of 33 hauling cars, 3 tractors, one of which had a two-wheeled trailer, and 3 Renard trains each having 4 trailers. The vehicles were divided into two convoys, one of which was exclusively made up of hauling cars, while the other comprised the tractors and the Renard trains. Each of the convoys furnished the supplies for an army corps and comprised three sections, of which two sections supplied one division each, while the third section was allotted to a non-divisioned part (cavalry or artillery).

The convoys started each morning from their working point, this being the railroad depot where the supplies of provisions were received and loaded, and they proceeded thence to furnish the supplies for the regiments, coming back to the starting point where they were reloaded in order to be ready to start out on the following morning. The distances covered per day were 40 miles at a minimum and 68 miles at a maximum, the mean being 56 miles. During the outward trip the cars were loaded with an average of 2,500 to 3,000 (long) tons of oats, sugar, or coffee, or with 1,500 to 2,000 tons of bread. However, all the cars were not employed each day for the supplies. Some of them, at least one per section, were used entirely for the soldiers who accompanied the convoys. Besides this, one car per section was often left in reserve so as to assure a rest period by turns. The data as to the fuel consumption will be given at a later period to the Technical Commission. This data will necessarily be of a very general nature, as the fuel and oil consumed were only taken account of for a group of cars of the same make and throughout the entire duration of the maneuvers. At present it may be said that the consumption seems to be lower than for the preceding maneuvers.

It was not desired by the military authorities to renew in 1908 the exploits which were accomplished during the maneuvers of 1907, from the standpoint of the distances covered, but it was desired to demonstrate that with vehicles such as could be furnished in time of need, it was possible to form units which are capable of running regularly and keeping together when transporting army supplies. From the standpoint of regularity, an excellent demonstration was made, and during the whole period of the maneuvers it never occurred that a convoy was five minutes behind time at a stated point of arrival. As for keeping

together, a considerable progress was noted in this direction also. None of the sections kept in very good order during the operations, but it is possible to do still better in this direction, and to so perfect the machines that they will not show fatigue when running in convoys with the cars spaced close together, and with only a sufficient distance between them to prevent any collision in the case of a sudden stop of one of the cars. The desiderata sought by the military authorities are chiefly simpler and stronger mechanical parts, and especially motors having pronounced flexibility.

SHIPS IN AIR AND WATER.*

SOME GENERAL RELATIONS BETWEEN THE TWO.

BY MAJOR GEORGE O. SQUIER, U. S. SIGNAL CORPS.

AT the present moment, so many minds are engaged upon the general problem of aerial navigation that any method by which a broad forecast of the subject can be made is particularly desirable. Each branch of the subject has its advocates, each believing implicitly in the superiority of his method. On the one hand the adherents of the dirigible balloon have little confidence in the future of the aeroplane, while another class have no energy to devote to the dirigible balloon, and still others prefer to work on the pure helicopter principle. As a matter of fact, each of these types is probably of permanent importance, and each particularly adapted to certain needs.

Fortunately for the development of each type, the experiments made with one class are of value to the other classes, and these in turn bear close analogy to the types of boats used in marine navigation. The dynamical properties of water and air are very much alike, and the equations of motion are similar for the two fluids, so that the data obtained from experiments in water, which are very extensive, may with slight modification be applied to computations for aerial navigation.

Helmholz's Theorem.—Von Helmholz, the master physicist of Germany, who illuminated everything he touched, has fortunately considered this subject, in a paper written in 1873. The title of his paper is "On a theorem relative to movements that are geometrically similar in fluid bodies, together with an application to the problem of steering balloons."

In this paper Helmholz affirms that, although the differential equations of hydro-mechanics may be an exact expression of the laws controlling the motions of fluids, still it is only for relatively few and simple experimental cases that we can obtain integrals appropriate to the given conditions, particularly if the cases involve viscosity and surfaces of discontinuity.

Hence, in dealing practically with the motion of fluids, we must depend upon experiment almost entirely, often being able to predict very little from theory, and that usually with uncertainty. Without integrating, however, he applies the hydrodynamic equations to transfer the observations made on any one fluid with given models and speeds, over to a geometrically similar mass of another fluid involving other speeds, and models of different magnitudes. By this means he is able to compute the size, velocity, resistance, power, etc., of aerial craft from given, or observed values for marine craft.

He also deduces laws that must inevitably place a limit upon the possible size and velocity of aerial craft without, however, indicating what that limit may be with artificial power. Applying this mode of reasoning to large birds he concludes by saying that, "It therefore appears probable that in the model of the great vulture, nature has already reached the limit that can be attained with the muscles as working organs, and under the most favorable conditions of subsistence, for the magnitude of a creature that shall raise itself by its wings and remain a long time in the air."

In comparing the behavior of models in water and air, he takes account of the density and viscosity of the media, as these were well known at the date of his writing, 1873; but he could not take account of the sliding, or skin-friction, because in his day neither the magnitude of such friction for air, nor the law of its variation with velocity had been determined.

SKIN-FRICTION IN AIR.

Even as late as Langley's experiments, skin-friction in air was regarded as a negligible quantity, but due to the work of Dr. Zahm, who was the first to make any really extensive and reliable experiments on skin-friction in air, we now can estimate the magnitude of this quantity. As a result of his research he has given in his paper on atmospheric friction the following equation:

$$f = 0.00000778\ l - ^{0.07}\ v^{1.88} \quad \ldots \quad (v = \text{ft. sec.})$$

$$f = 0.0000158\ l - ^{0.07}\ v^{1.88} \quad \ldots \quad (v = \text{mi. hr.})$$

in which f is the average skin-friction per square foot, and l the length of surface.

From this equation the accompanying table of resistances was computed, and is inserted here for the convenience of engineers:

FRICTION PER SQUARE FOOT FOR VARIOUS SPEEDS AND LENGTHS OF SURFACE.

Wind Speed, Miles Hour.	Average Friction in Pounds per Square Foot.					
	1 Foot Plane.	2 Foot Plane.	4 Foot Plane.	8 Foot Plane.	16 Foot Plane.	32 Foot Plane.
5	0.000303	0.000289	0.000275	0.000262	0.000250	0.000238
10	0.00112	0.00105	0.00101	0.000967	0.000922	0.000878
15	0.00237	0.00226	0.00215	0.00205	0.00195	0.00186
20	0.00402	0.00384	0.00365	0.00349	0.00332	0.00317
25	0.00606	0.00579	0.00551	0.00527	0.00501	0.00478
30	0.00850	0.00810	0.00772	0.00736	0.00701	0.00668
35	0.01130	0.0108	0.0103	0.0098	0.00932	0.00888
40	0.0145	0.0138	0.0132	0.0125	0.0125	0.0114
50	0.0219	0.0209	0.0199	0.0190	0.0181	0.0172
60	0.0307	0.0293	0.0279	0.0265	0.0253	0.0242
70	0.0407	0.0390	0.0370	0.0353	0.0337	0.0321
80	0.0523	0.0500	0.0474	0.0452	0.0431	0.0411
90	0.0650	0.0621	0.0590	0.0563	0.0536	0.0511
100	0.0792	0.0755	0.0719	0.0685	0.0652	0.0622

The numbers within the rules represent data coming within the range of observation. These observations show that "the frictional resistance is at least as great for air as water, in proportion to their densities. In other words, it amounts to a decided obstacle in high speed transportation. In aeronautics it is one of the chief elements of resistance both to hull-shaped bodies and to aero-surfaces gliding at small angles of flight."

Relative Dynamic and Buoyant Support.—Peter Cooper-Hewitt has given careful study to the relative behavior of ships in air and in water. He has made a special study of hydroplanes, and has prepared graphic representations of his results which furnish a valuable forecast of the problem of flight.

Without knowing of Helmholz's theorem, Cooper-Hewitt has independently computed curves for ships and hydroplanes from actual data in water, and has employed these curves to solve analogous problems in air, using the relative densities of the two media, approximately 800 to 1, in order to determine the relative values of support by dynamic reaction and by displacement for various weights and speeds.

An analysis of these curves leads to conclusions of importance, some of which are as follows:

The power consumed in propelling a displacement vessel at any constant speed, supported by air or water, is considered as being two-thirds consumed by skin-resistance, or surface resistance, and one-third consumed by head resistance. Such a vessel will be about ten diameters in length, or should be of such shape that the sum of the power consumed in surface friction and in head resistance will be a minimum (torpedo shape).

The power required to overcome friction due to forward movement will be about one-eighth as much for a vesssel in air as for a vessel of the same weight in water.

Leaving other things out of consideration, higher speeds can be obtained in craft of small tonnage by the dynamic reaction type than by the displacement type; for large tonnages the advantages of the displacement type are manifest.

A dirigible balloon carrying the same weight, other things being equal, may be made to travel about twice as fast as a boat for the same power; or be made to travel at the same speed with the expenditure of about one-eighth of the power.

As there are practically always currents in the air reaching at times a velocity of many miles per hour, a dirigible balloon should be constructed with sufficient power to be able to travel at a speed of about 50 miles per hour, in order that it may be available under practical conditions of weather. In other words, it should have substantially as much power as would drive a boat, carrying the same weight, 25 miles an hour, or should have the same ratio of power to size as the "Lusitania."

Motors.—It is the general opinion that any one of several types of internal-combustion motors at present available is suitable for use with dirigible balloons. With this type lightness need not be obtained at the sacrifice of efficiency. In the aeroplane, however, lightness per output is a prime consideration, and certainty and reliability of action is demanded, since if by chance the motor stops, the machine must immediately glide to the earth. A technical discussion of motors would of itself require an extended paper, and may well form the subject of a special communication.

Propellers.—The fundamental principles of propellers are the same for air as for water. In both elements the thrust is directly proportional to the mass of fluid set in motion per second. A great variety of types of propellers have been devised, but thus far only the screw-propeller has proved to be of practical value in air. The theory of the screw-propeller in air is substantially the same as for the deeply submerged screw-propeller in water, and therefore does not seem to call for treatment here. There is much need at present for accurate aerodynamic data on the behavior of screw-propellers in air, and it is hoped that engineers will soon secure such data, and present them in practical form for the use of those interested in airship design.

Limitations.—Euclid's familiar "square-cube" theorem connecting the volumes and surfaces of similar figures, as is well known, operates in favor of increased size of dirigibles, and limits the possible size of heavier-than-air machines in single units and with concentrated load.

It appears, however, that both fundamental forms of aerial craft will likely be developed, and that the lighter-than-air type will be the burden-bearing machine of the future, whereas the heavier-than-air type will be limited to comparatively low tonnage, operating at relatively high velocity. The helicopter type of machine may be considered as the limit of the aeroplane, when by constantly increasing the speed, the area of the supporting surfaces is continuously reduced until it practically disappears. We may then picture a racing aeroplane propelled by great power, supported largely by the pressure against its body, and with its wings reduced to mere fins which serve to guide and steady its motion. In other words, starting with the aeroplane type, we have the dirigible balloon on the one hand as the tonnage increases, and the helicopter type on the other extreme as the speed increases. Apparently, therefore, no one of these forms will be exclusively used, but each will have its place for the particular work required.

* Abstracted from a paper read before the American Society of Mechanical Engineers.

BRICK FROM BURNED GARBAGE.

AT Woolwich and at Nelson, England, garbage is incinerated in furnaces. The combustion gases, after heating boilers in which steam is produced for the generation of an electric lighting current, flow through tubes surrounded by air, which is thus heated to 300 deg. F. and is then blown through the furnaces. The operation leaves a large quantity of clinkers, composed of silica, alumina, lime, and iron, with a little magnesia, potash and soda, which is utilized in making sand-lime brick. The ground clinkers are mixed with quicklime and about ten per cent of water, to form a soft mortar, which is stored in brick cisterns for a day or two to insure the complete slaking of the lime, and then goes to the brick-making machine. The fresh bricks are placed in closed vessels and subjected for eight or ten hours to the action of steam at eight atmospheres pressure. When taken out the bricks are sufficiently hard for immediate use.

The hardening is caused, as in the case of ordinary sand-lime brick, by the combination of the lime with the silica of the clinkers, at the high temperature of the steamer. The quality of the Nelson garbage brick is equal to that of good blue Staffordshire brick, except that it is rather more hygroscopic. Large building blocks and pavement tiles are made by similar processes.

Gerner's Heveenoid.—This is a caoutchouc substance which, compared with previous caoutchouc substances, is said to possess superior flexibility, durability and insolubility. According to its character, heveenoid is made up of India rubber, camphor, and sulphur. Soft heveenoid consists of 2 parts of rubber and camphor, 1/16 part of lime and ½ part of sulphur; hard heveenoid of 2 parts each of rubber and camphor, ½ part glycerine and 8.2 parts of sulphur.

PRESSURE OF THE ATMOSPHERE ON LIQUIDS.

CONDITIONS OF EQUILIBRIUM IN LIQUIDS OF THE SAME AND DIFFERENT DENSITIES.

BY FRANKLIN VAN WINKLE.

A BODY is said to be in equilibrium when the resultant of all forces acting upon it produces a condition of rest. If from any cause there is a greater pressure exerted upon one point than upon other parts of a liquid, particles will flow from the higher to the lower points

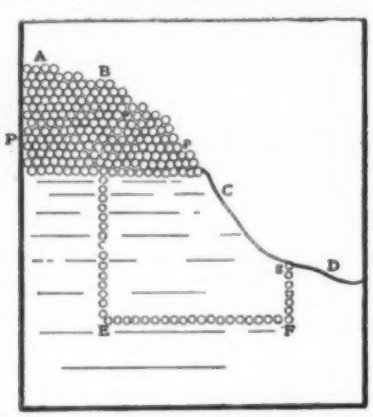


FIG. 1.—LIQUID MASS UNBALANCED LATERALLY AND VERTICALLY.

of pressure in re-establishing equality of pressure and equilibrium of the liquid mass. As a consequence, if a quantity of liquid is confined in a vessel, its surface to be at rest must be horizontal. For if it has any other form, as *A B C D*, Fig. 1, a column of particles, as *A P*, exerting pressure at *P*, is unbalanced laterally by horizontal layers of particles like *P p*, or vertically by the difference in heights of columns like *B E* and *F g*. In absence of an equal and contrary pressure to hold the surface particles in their position, as shown in Fig. 1, they are pushed laterally and upward as shown by the changed positions of *p* and *g* in Fig. 2. This action takes place simultaneously over the whole surface, the depressed portion *B C* being filled or raised as

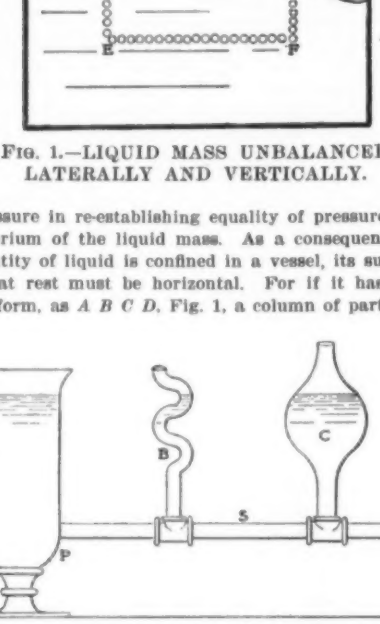


FIG. 6.—BALANCING COLUMNS OF MERCURY AND WATER.

rapidly as the change of form can be accomplished by gravity acting on the elevated portions of the liquid, until both lateral and vertical equilibrium have been established. This can only be after the surface particles have arranged themselves in a horizontal plane, as shown in Fig. 3.

EQUILIBRIUM IN COMMUNICATING VESSELS.

When vessels of any given shape or size are in communication, and each contains liquid of the same density, there will be equilibrium when the surfaces of the liquids in each of the vessels are on the same level. Suppose the vessels *A*, *B*, *C*, *D* and *E*, Fig. 4, to communicate with each other by means of the pipe *P p*.

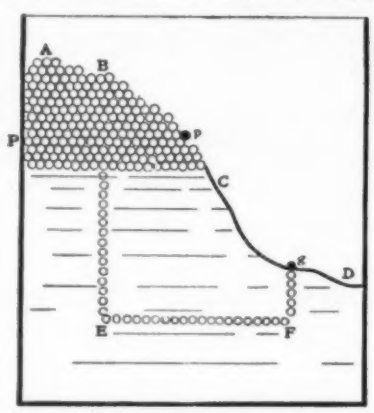


FIG. 2.—GRAVITY ESTABLISHING EQUILIBRIUM.

Then considering any cross section of this connecting pipe as at *s*, equilibrium can exist in this section only as long as the pressure from *P* toward *p* equals the pressure from *p* toward *P*, and the same will be true of any other section. Pressure from *A* toward *E* may be considered as counterbalancing the pressure from *E* toward *A* and the vertical-column pressure due to *B*, *C* and *D* may each be considered as counterbalancing the upward pressure in the pipe *P*. The pressure at any section of *P* is equal to the weight of a column of the liquid whose base has the same area as the section and whose height is measured vertically from the center of pressure of the section. In order for this to be so, the same vertical-column pressure must be produced in the connecting pipe *P* on all sections which are at the same level. It therefore follows that, for equilibrium there must be equal column pressures from all the connecting vessels, i. e., the surfaces of liquids in each of the vessels must be in the same level.

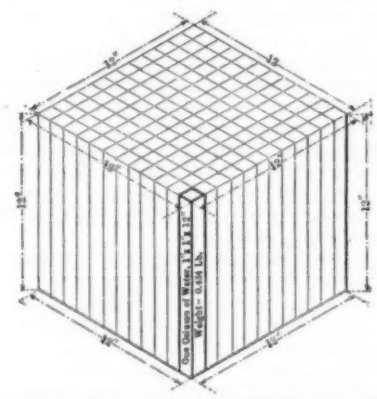


FIG. 7.—ONE CUBIC FOOT OF WATER DIVIDED INTO 144 COLUMNS 1 x 1 x 12 INCHES.

EQUILIBRIUM OF LIQUIDS OF DIFFERENT DENSITIES.

It must be evident from the foregoing that if liquids of different densities are placed in the different vessels, the relative heights of the columns will vary and equilibrium will be established in the connecting pipe *P* by dissimilar levels, according to the densities of the liquids.

Fig. 5 represents the same apparatus as Fig. 4, differing only in having a stop cock placed in each of the vessels *B*, *C* and *D*, near its point of junction with the connecting pipe *P*. With these stop cocks closed we will suppose the connecting pipe *P* and vessels

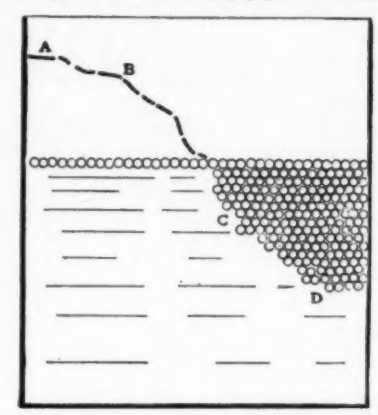


FIG. 3.—SURFACE PARTICLES IN HORIZONTAL PLANE AND EQUILIBRIUM ESTABLISHED.

and *E* to be filled with water to a height of about 1 inches above the level of the stop cocks. It is evident that equilibrium in the pipe *P* will be destroyed by opening the stop cocks, unless the upward pressure at the stop cocks is counteracted by an equal downward

FIG. 4.—SURFACE OF WATER COLUMNS AT SAME LEVEL.

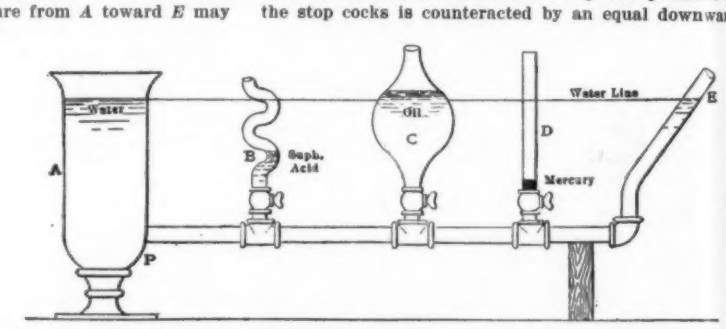


FIG. 5.—BALANCING LIQUID COLUMNS OF DIFFERENT DENSITIES

pressure. This pressure may be created as before by filling all the vessels with water to the same level, or we may fill each with liquids of any density to a sufficient height to create the same hydrostatic pressure as that created by the water in the vessels *A* and *E*. The weight of mercury being 13.6 times that of water,

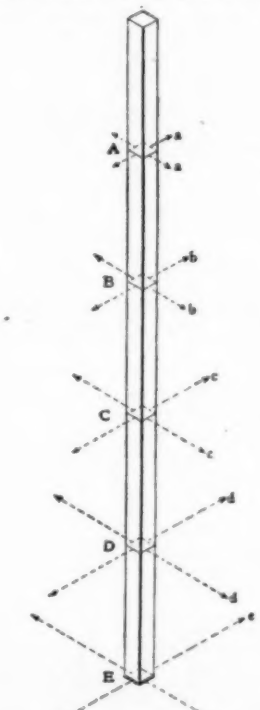


FIG. 8.—LATERAL AND VERTICAL PRESSURES EQUAL.

* Power and the Engineer.

1 inch depth of mercury in one of the vessels, as *D*, would result in pressure equal to 13.6 inches of water, while olive oil, being about 92 per cent the weight of water, will have to be filled in one of the vessels, as *C*, to a height of about 14¾ inches; and sulphuric acid, with a specific gravity of 1.85 times that of water, introduced into one of the vessels, as *B*, would have to be filled to a height of about 7⅜ inches.

Having filled the different vessels to the respective

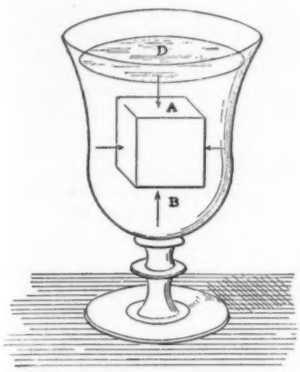


FIG. 9.—CUBE IMMERSED IN WATER.

FIG. 10.—IRREGULAR OBJECT IN WATER.

heights, the stop cocks may be opened without disturbing the relative heights of the liquids, as the downward pressure from each will balance the upward pressure from the connecting pipe *P*.

HEIGHTS OF BALANCED COLUMNS ARE INVERSELY AS THE DENSITIES.

The heights above the horizontal surface of contact of two columns of liquids in equilibrium are inversely as their densities. To show this experimentally, mercury is poured into a bent glass tube *M N*, Fig. 6, fixed against an upright wooden support, and then water is poured into one of the legs *A B*. The column of water *A B* pressing on the mercury at *B* lowers its level in the

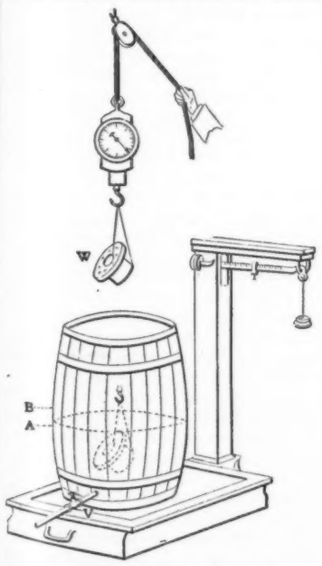


FIG. 11.—BUOYANCY EQUALS WEIGHT OF WATER DISPLACED.

leg *A B* and raises it in the leg *C D*. If, when equilibrium is established, we imagine a horizontal plane *B C* to pass through *B*, the column of water in *A B* will balance the column of mercury *C D*. Upon measuring the heights of these two columns, it will be found that the height of the column of water *A B* is about 13.6 times that of the column of mercury, measuring upward from the same level *B C*. The density of mercury is about 13.6 times that of water, from which it follows that the heights are inversely as the densities.

Again referring to Fig. 6, it will be readily understood that if the column *A B* is of uniform size, then the weight of the water column *A B* will be the amount of pressure exerted by the water in *A B* upon the surface of the mercury at *B*, and that the pressure on *B* will be directly in proportion to the height of the water column in *A B*.

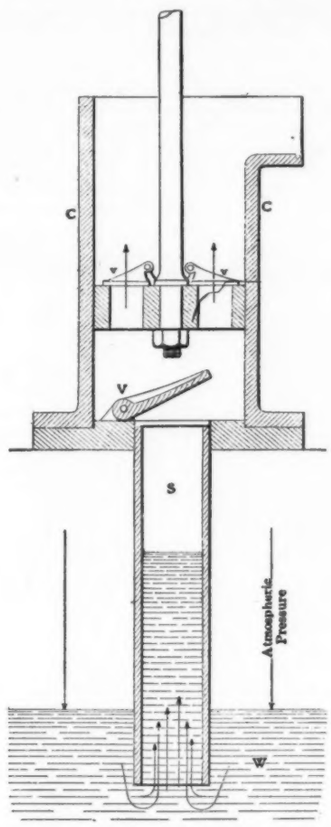


FIG. 13.—ORDINARY SUCTION PUMP.

PRESSURE DUE TO HEAD.

We have seen, however, that the same intensity of pressure on the liquid surface *B* results from the same vertical height or head of liquid above *B*, regardless of whether the containing surface above *B* is a straight tube or of any other size or form, such, for instance, as is shown in Fig. 4.

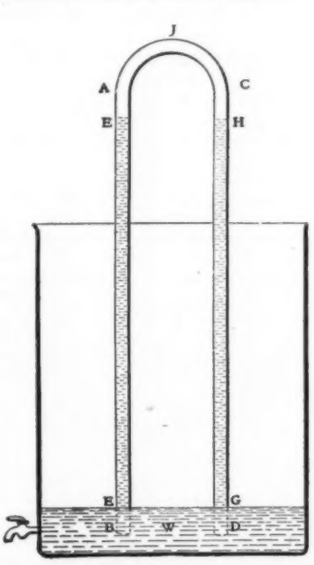


FIG. 15.—ATMOSPHERIC PRESSURE SUSTAINING WATER COLUMN 34 FEET HIGH.

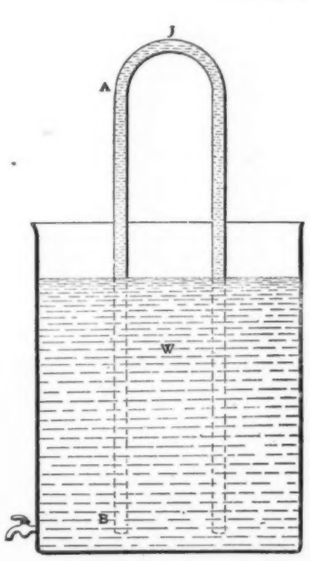


FIG. 16.—PRESSURE IN BOTH LEGS BALANCED.

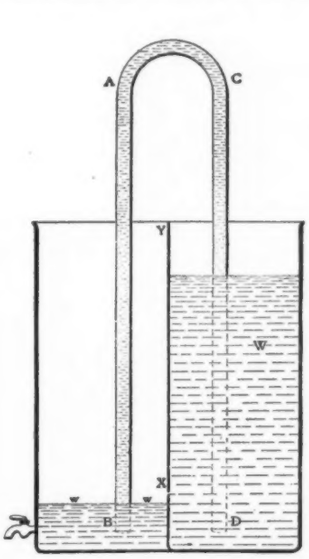


FIG. 17.—UNBALANCED PRESSURE.

It therefore follows that pressure to which the surface of a liquid is exposed, can be measured by the height or head of liquid column which that pressure can support.

The truth of this principle is of the greatest convenience in practical estimates and computations, from the fact that nearly all questions in hydraulics involve considerations both of pressures and differences of level. It is therefore customary in practical hydraulics to express pressures in feet of head, meaning thereby actual or equivalent pressure of a column of water of given height or head acting on a unit area of surface.

In ordinary computations, the weight of a cubic foot of water is taken at 62.5 pounds. As indicated

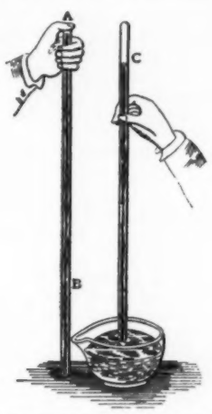


FIG. 12.—TORRICELLI'S EXPERIMENT.

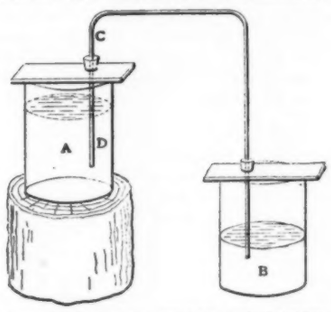


FIG. 14.—SIPHONING FROM A HIGHER TO A LOWER LEVEL.

in Fig. 7, a cube of water, 12 x 12 x 12 inches, may be considered as divided into 144 columns, each 1 foot high with a base 1 inch square. The pressure due to a column of water 1 foot high, with a base 1 inch square, is therefore

$$\frac{62.5}{144} = 0.434$$

pound. Consequently, the hydrostatic pressure of water is 0.434 pound per square inch for each foot of head. When it is desired to find the pressure in pounds per square inch due to any given head, we have simply to multiply the head, measured in feet, by 0.434; for example, the pounds pressure per square inch resulting from a 50-foot head of water, would be

$$50 \times 0.434 = 21.7$$

pounds per square inch.

LATERAL PRESSURE.

It should be readily understood that the pressure

on each horizontal layer of a vertical column of liquid is directly in proportion to its depth. Now as the intensity of pressure from any particle is the same in every direction, it follows that with a given height of column, as *A B C D E*, Fig. 8, lateral pressure *A a*, *B b*, *C c*, *D d* and *E e* will be the same per unit of area as the vertical pressure on the corresponding horizontal layers of the column at the same depths.

If *A E* is assumed to be a tube filled with water, every point on each side of the tube will be subjected to a pressure directly in proportion to the head, that is to say, a point in the side of the tube acted upon by a head of 1 foot, would have to resist pressure of the intensity of 0.434 pound per square inch; and by a 50-foot head a pressure of

$$50 \times 0.434 = 21.7 \text{ pounds.}$$

PRESSURE UPON AN IMMERSED BODY.

When a solid is immersed in a liquid, every portion of its surface is subjected to pressure which increases with the depth of the liquid.

Imagine a cube to be immersed in a mass of water, Fig. 9. Opposing pressures on the four sides are evidently in equilibrium. Considering the pressures exerted on the upper and lower faces *A* and *B*, we can readily understand that downward pressure on the upper face *A* will amount to the same thing as the downward pressure of a column whose base is *A* and whose head is *A D*. The lower face *B* is pressed upward with the same intensity as the weight of a column having the height *B D* and base equal to the lower face *B* of the cube. The cube is, therefore, urged upward by a force equal to the difference between these two pressures, that is to say, the upward pressure is equal to the weight of a column of water the size of the cube itself. Otherwise expressed, upward pressure is equal to the weight of the volume of water displaced.

Thus, it becomes evident that every body immersed in a liquid is pressed upward by a force equal to the weight of the displaced liquid; for, suppose a portion of the liquid to become solidified in any given shape without change of volume, as *C* in Fig. 10. The solid thus formed will remain at rest and would therefore have to be acted upon upward by a force just equal to its weight. If, in place of the solidified water *C* we substitute any other liquid or solid substance occupying the same space, it would receive the same pressures from the surrounding liquid as the solidified portion had received, and would be subjected to the same upward pressure as the equal volume of solidified liquid had received, that is to say, equal to the amount of liquid displaced.

The preceding principles prove that whenever a body is immersed in a liquid, it is subjected to two forces, viz., gravity, which tends to lower it, and buoyancy of the liquid, which tends to raise it with a force equal to the weight of the liquid displaced. So that when a body is immersed in a liquid, it loses part of its weight equal to the weight of the displaced liquid. This principle, named after the discoverer, is called the principle of Archimedes. It may be determined experimentally with the apparatus shown in Fig. 11.

An open barrel, provided with an outlet and stop valve *V* near the bottom, is placed on a platform scales and partly filled with water, as for instance to the level indicated by the dotted line *A*. The level of water is then to be marked by driving three or more small nails around the inside of the barrel at the surface of the water at approximately equal distances apart. The gross weight on the platform scales is then noted. Any solid mass of material, as *W*, is then suspended in the air from a spring balance, as shown in the figure, and its weight noted. Then, with *W* still suspended from the spring scales, the latter is lowered until *W* is submerged in the water contained in the barrel below the original level *A*.

As soon as any portion of the mass *W* becomes submerged, the spring scales will be found to indicate less weight from *W* than when suspended in the air. Another thing observable is that as *W* becomes submerged, the water contained in the barrel gradually rises until *W* is completely submerged. Suppose, when complete submergence of *W* takes place, that the level of the water has risen to the level *B*; then the volume of water between the levels *A* and *B* will evidently be the volume of water displaced by *W*. Now, with *W* still suspended under water, note the weight shown by the spring balance and also note the new weight shown on the platform scales. It will be found that the spring scales has lost precisely the same weight that the weight on the platform scales has increased. If water is now discharged from the barrel by the valve *V* until its level is reduced to the original level *A*, with *W* still submerged, the weight indicated by the platform scales will be found to be the same as originally indicated. Then, upon withdrawing *W* from the barrel, the weight on the platform scales will be found to be as much less than the original weight, as the difference in weight of *W* when weighed in air and when weighed in water. This difference in weight is the buoyant effect of the water, which is just equal to the weight of the volume of water which was displaced by the body *W*.

As a small discrepancy is liable to be introduced in the above comparisons of weights due to unequal displacements of water by the cord or rope by which *W* is suspended, each time *W* is suspended for the purpose of observing weights with *W* submerged, the same amount of cord or rope should be submerged below the surface of the water in the barrel.

INFLUENCE OF THE ATMOSPHERE.

Both by its pressure and mixture with liquids, the atmosphere exerts such important influences over the pressure and flow of liquids as to require special consideration. By the following experiment, Torricelli, while a pupil of Galileo in 1643, was the first to make an exact demonstration of the pressure exerted by the atmosphere. His demonstration of this is as follows:

Referring to Fig. 12, a stout glass tube *A B* about 36 inches long, sealed at one end, is nearly filled with mercury. The open end *A* being closed by the thumb, the tube is inverted, the open end placed in a mercury trough and the thumb removed. The tube being held in a vertical position, the column of mercury sinks, and after oscillating up and down in the tube for a short time, the mercury finally comes to rest at a height *C*. When the experiment is performed at the level of the sea, the height of the column of mercury will be about 30 inches above the level of the mercury in the trough. The column of mercury is sustained in the tube by the pressure of the atmosphere on the mercury in the trough. There is no downward pressure on the upper surface of the mercury, because the tube is closed. Should the upper end of the tube be opened, the atmosphere would press equally inside and outside the tube and the mercury would sink to a common level with the mercury in the trough. We have already seen that the heights of two columns of liquid in communication with each other will be inversely as their densities, hence it follows that at sea level the pressure created by the atmosphere will be the same as that of a column of mercury about 30 inches high.

If we measure the height of such a column of mercury from time to time, we find that it varies according to the condition of the atmosphere. As we carry this apparatus to places of higher elevations above sea level, we find that the liquid column settles to a less height, indicating as it should, less pressure of the atmosphere. This is the principle of operation of the mercurial barometer.

It has been demonstrated that the pressure of the atmosphere will sustain a column of water or any other liquid in the same manner, but the heights of the columns so sustained will be inversely as the densities of the liquids. Mercury is 13.6 times the weight of water, so at sea level a column of water should rise to a height of

$$30 \times 13.6 = 408$$

inches or 34 feet under pressure of the atmosphere, which Torricelli found to be the case.

The pressure per square inch which will be created at the foot of a column of mercury 30 inches high, will be the same as the weight of 30 cubic inches of mercury. This is very nearly equal to 14.7 pounds, therefore the pressure of the atmosphere, in order to sustain a column of mercury 30 inches in height, must amount to 14.7 pounds per square inch, and this is the pressure per square inch actually considered due to the atmosphere. But when the pressure of the atmosphere is to be taken into account for a place whose elevation is considerably above sea level, or where the height of the barometric column has considerable deviation from 30 inches, proportionate values are also to be taken for the pressure of the atmosphere and the height of a column of water which would be sustained by the atmosphere.

The action of atmospheric pressure on the free surface of liquids is well illustrated in the operation of an ordinary suction pump, and may be readily understood by referring to Fig. 13. In the figure, *C C* represents a pump cylinder with an inlet valve *V* opening inward and a piston with one or more valves *v v*, also opening upward. In the beginning of the operation, when the piston is drawn upward, the valves *v v* in the piston are closed by the pressure of the atmosphere and a partial vacuum is formed below the piston. Relief of pressure from the top of the valve *V* causes it to rise on account of the presence of full atmospheric pressure of air in the suction pipe *S*, resulting in reduction of pressure in *S*. Full atmospheric pressure simultaneously acting on the surface of the water *W*, causes the water to rise in *S* until equilibrium is established, which will be when the pressure due to the height of the water in the suction pipe combined with the pressure on top of the column is equal to the atmospheric pressure acting on the surface of the water *W*.

When the piston descends, the valve *V* will close, while the valves *v v* in the piston will open and allow the air in the space below the piston to escape. Thus it appears that each double stroke of the piston removes some air from the cylinder, thereby lessening the pressure above the liquid column in *S*, causing it to rise higher and higher from the action of the atmospheric pressure on *W*, until it finally fills the lower part of the pump cylinder and is discharged continuously in the same manner as the air was discharged in the beginning.

In the beginning of operation of the suction pump it is impossible to create a perfect vacuum by the removal of all air pressure from the top of the liquid column. The height of liquid column raised in the suction pipe *S* by the pressure of the atmosphere on *W* can, therefore, never be equal to the height of liquid column which, acting without superimposed pressure, would be equal to the pressure of the atmosphere.

When pressure of the atmosphere is capable of sustaining a mercury column 30 inches high, we have seen that this pressure will be equal to the pressure of a column of water 34 feet in height. Consequently, when the barometric reading is 30 inches or less, atmospheric pressure would not force water above the valve *V* into the space above the piston unless the vertical distance of *V* is less than 34 feet above the surface of *W*.

SIPHONAGE.

In its simplest form the siphon consists of a U-shaped tube by means of which water or other liquids may be conveyed by atmospheric pressure from a given level, over a higher elevation, to a lower level, as from vessel *A* to vessel *B*, Fig. 14. The usual method of setting the siphon in action is to fill the tube with the liquid, close the ends and place the shorter branch or leg in the vessel to be emptied, and then open the ends, when flow will ensue from the higher to the lower level, and will continue as long as the liquids in the two vessels are at different levels and the leg *C D* dips into the liquid. The action of siphonage may be better understood from the following considerations:

If, in Fig. 15, the U-shaped tube *A B C D* first filled with water, is afterward erected with its ends submerged, water will remain standing in both legs of the U-tube by virtue of atmospheric pressure on the surface of the liquid *W*. The height at which the water will stand will not, however, exceed the height of a column which will produce pressure in excess of the pressure of the atmosphere. With ordinary pressure of the atmosphere, two columns of water *E F* and *G H*, each 34 feet high, could be sustained above the surface of the water *W*, the space in the tube above the levels of *E* and *H* being a vacuum.

By raising the level of the water in *W*, it is evident that the liquid columns would rise until they completely filled the vacuum space *E J H*, the pressure at *J* being zero, as before. By further raising the level of the water surface *W*, as shown in Fig. 16, each of the columns would have a height less than the height of column capable of being supported by atmospheric pressure on the surface of the water *W*. Nevertheless, upward pressure in the legs at the new surface of *W* would be equal to the pressure of the atmosphere, to balance which there must be an equal downward pressure from the columns. The height of column being less than necessary to produce this downward pressure, equilibrium can exist only by virtue of pressure within the liquid at the crest of the bent portion *J*, to make up the difference between the pressure due to the height of a column like *E E* or *G H*, in Fig. 15, and the pressure due to gravity of a column having a vertical height of the crest *J* above the surface *W*.

If, as shown in Fig. 17, we place a partition *X Y* through the vessel containing the liquid, and draw down the liquid on one side of the partition to a level *w w*, then, from the fact that water in the leg *A B* stands higher above the surface *w w* than water in the leg *C D* stands above the surface of *W*, it follows that pressure due to gravity of the column *A B* will be greater at the surface *w w* than the pressure due to gravity of the column *C D* at the surface of *W*. In consequence of this there will be less pressure within the upper end of *A B* to help balance atmospheric pressure at *w w*, than in the upper end of *C D* to help balance atmospheric pressure at the surface of *W*. Hence, flow will take place from the leg *C D* over to the leg *A B*, being due to the fact that the pressure from *C* to *A* is greater than the pressure from *A* to *C*, their difference in pressure being equal to the pressure which would be created by a column whose height would extend from the level of the surface *w w* to that of the surface of *W*.

It follows, therefore, that the elevation over which a liquid can be siphoned cannot exceed the height of a column of that liquid which the atmospheric pressure will support; and also that the pressure which produces siphonage will depend upon the difference in level of the liquids in the two vessels.

The proper construction of radiators is a matter which deserves more serious consideration on the part of the automobile manufacturer. A radiator ought to be made of separate tubes for the sake of the readiness with which repairs can be made and for the sake of good workmanship, appearance, durability, and efficiency.

MEASURING JOY AND SORROW.

THE PSYCHOGALVANIC REFLEX AS A DETECTOR OF EMOTION.

BY DR. OTTO VERAGUTH.

THE psychogalvanic reflex is a peculiar physical manifestation of mental processes, in the form of a change in the electrical properties of the skin. This change occurs whenever the subject feels an emotion and it can be detected and measured with a sensitive galvanometer.

The point of a needle, connected with one pole of a sal-ammoniac battery, is thrust through the skin of the palm of the hand, in a normal person, and, after the smart of the wound has passed, a steel plate, connected with the other pole of the battery, is laid on the skin, near the needle. An electric current now flows through the skin between the needle and the plate. The strength of this current is indicated by a sensitive galvanometer composed of two fixed coils and a suspended coil, which takes the place of a magnet and carries a mirror. If the subject remains at rest and undisturbed by emotion the galvanometer reading is found to decrease, at first rapidly and then more slowly, indicating a corresponding increase in the resistance of the skin, but any stimulus which produces an emotion also produces a temporary decrease in the resistance of the skin, which is indicated by an increased deflection of the galvanometer.

If the galvanic cell is removed from the circuit the galvanometer again shows a deflection, varying within wide limits, when an emotional stimulus is applied. This effect is due, not to a change in resistance, but to the variation caused by emotion in the electromotive force resident in the skin. These experiments, especially the first one, can be greatly simplified. The skin need not be pierced. It is sufficient to immerse the hands of the subject in two vessels of lukewarm brine connected with the battery and galvanometer, or to press the palms of the hands or the soles of the feet on plates of metal, similarly connected.

In all cases the deflection gradually diminishes during perfect mental calm, and is suddenly increased by emotion. The stimulus may be a flash of light, a sharp whistle, a prick with a needle, or a word, spoken or written. In order to affect the galvanometer, the stimulus must produce an emotion or feeling of some kind. For example, the steady decrease of the deflection is not interrupted by reading uninteresting matter, but a word that awakens interest always increases the deflection. In order to study the action of verbal stimuli I have adopted the method of calling out a series of disconnected words, including a word or two of especial interest to the person under examination. For example, I examined an architect whose plan for a house had been severely criticised by a builder. I read aloud a list of indifferent words, such as tree, sing, yellow, mountain, book, etc., introducing the builder's name and a contemptuous expression which he had used. In these two instances deflections of 24 and 33 scale divisions were produced while none of the other words affected the galvanometer at all. In examining a student of the University of Zürich I used the name of a town in the vicinity and was surprised by the great deflection that followed. The student explained that he had been arrested for dueling in that town.

If the effective words are repeated at short intervals the deflections caused by them gradually diminish. The time required for the effect to disappear entirely varies greatly with the individual and the emotion.

Before I published the needle experiment the objection had often been made, to experiment with metallic electrodes in contact with the hands, that the deflection of the galvanometer indicated nothing but a change in the conditions of contact caused by involuntary movements. But this interpretation is made very improbable by the constancy of the phenomenon with other methods of experiment and also by the fact that an interval, sometimes of more than six seconds, elapses between the application of the verbal or other stimulus and the sudden deflection of the galvanometer. An involuntary movement of the hands would take place more promptly. Imagine an actor waiting six seconds before imitating the involuntary movement of alarm evoked by a terrifying occurrence!

This interval between the stimulus and the movement of the galvanometer is one of the peculiarities of the psychogalvanic reflex that may aid us in discovering its nature. The length of the interval and all other phases can be recorded by well known photographic methods. The curve obtained in this way often shows, before the great deviation, a small deviation in the opposite direction, which considerably shortens the latent interval. Often, also, a strong stimulus is followed by several oscillations, and the deviations caused by successive stimuli of the same kind gradually diminish. The same peculiarities have been observed in galvanic reflexes of plants, certain animal tissues and, especially, electric fishes. The results which I have already obtained have been confirmed by many other observers, and they suggest many interesting possibilities.

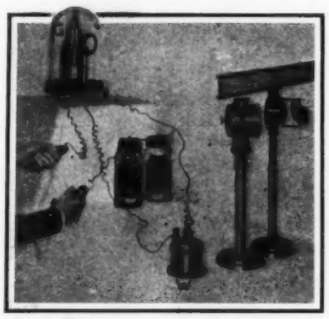


FIG. 1.—APPARATUS FOR MEASURING PSYCHOGALVANIC REFLEX.

G. Galvanometer. L. Lamp. S. Scale. W. Resistance.

In the first place, human psychology possesses in the psychogalvanic reflex an objective indication of emotions which, in contrast to many other forms of expression, is free from ambiguity and apparently from control by the will of the subject. We cannot prevent the electric confession of our skins.

The application of psychogalvanic association experiments to criminal investigations has often been recommended and it is said that this method has been employed in America with brilliant success. I do not advise this course. Let us suppose that a man suspected of crime is examined by this method. A reflex produced by an allusion to the crime would not prove the man's guilt, for it might be caused by the interest

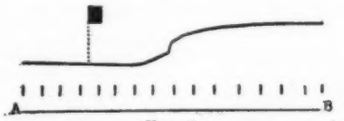


FIG. 2.

Curves of deflection produced by pricking the scalp at the instant indicated by the black square. The vertical marks denote seconds.

in the crime which would naturally be felt even by an innocent suspect. Close study of the phenomenon has shown the danger of jumping at psychological conclusions. The irritability of the human mind is a very complex function, the galvanometer deflection a very simple movement.

The psychogalvanic reflex will undoubtedly be of service in animal psychology. It has already been discovered that the reflex can be produced in normal cats and dogs, but not in cats under the influence of narcotics.

In medicine, the reflex affords a trustworthy and indeed the only objective indication of changes in sensibility, but many precautions must be observed in its employment and interpretation. One result of

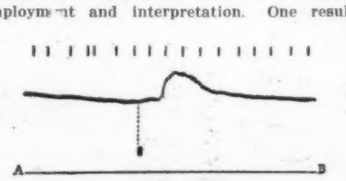


FIG. 3.

Curve of reflex produced by a sound emitted at the instant indicated by the ordinate below. The vertical marks denote seconds.

great theoretical interest has already been obtained. A stimulus applied to a part of the body which has lost its sensitiveness through the severance of a nerve trunk produces no effect on the galvanometer. But there is an insensibility due to hysteria. Some hysterical patients, when certain parts of the skin are cut or burned, show no symptom of pain and assert that they feel nothing. But the stimulation of these same parts produces the same effect on the galvanometer that is observed in the case of normal persons.

In these cases, as in all others, the electrodes should be applied to the palms of the hands or the soles of the feet, which give far stronger reflexes than any other part of the body, probably because they are more abundantly supplied with sweat glands. In the palm the reflex can be almost destroyed by the local application of belladonna, which arrests the secretion of sweat, but it is little affected by stopping the circulation of blood, freezing, or paralyzing the sensory nerves.

The history of the psychogalvanic reflex is very curious. The phenomenon appears to have been first observed by the French physiologist Féré, in 1888. In 1890 it was rediscovered by the Russian Tarchanow, but his work, like Féré's, attracted little attention, although his results were confirmed by a few other observers. In 1904, the writer, ignorant of the work of his predecessors, undertook the investigation of an electrical phenomenon observed by E. R. Mueller, of Zürich, and was thus led to the researches which are here briefly described. My results have been confirmed by many others, and especially by psychologists. The escape of the third discovery of the phenomenon from the fate of the first and second is due to the astonishing progress which has been made in this branch of science in the last ten years.—Umschau.

A HANDY SACK-HOLDER.

THOSE who have to dispatch their produce in sacks, especially millers, lime-burners, and so forth, readily realize the difficulties attending the charging of the bags. One man or boy has to be deputed to hold the mouth of the sack open while it is being filled. An ingenious means of overcoming this difficulty has been effected by an engineer attached to one of our large gasworks, where the uneconomical labor conditions attending the prevailing system were recognized, and caused him to devise a highly efficient and simple mechanical holder. It comprises a small stand, upon which is mounted an upright pillar. Upon this pillar slides a collar carrying a lever. The longer end of the lever serves as the handle, and the shorter length the sack-holder. The bag is held in the distended position by two rings hinged together. The sack is placed through the lower ring and the mouth pressed over the rim all round. The upper ring is then lowered, and by means of a series of short spikes which pierce the sacking and pass through holes in the lower ring when it is pressed down the bag is held wide open. When the bag is filled the upper ring is simply swung back and the mouth of the sack left free for tying or sewing up. The apparatus is strongly made, is inexpensive, and easily operated, while it can be adjusted to handle any capacity of sack.—Chambers's Journal.

It will be remembered that the French biologist Yves Delage succeeded over a year ago in producing artificial fertilization of sea urchins' eggs by means of chemical reagents, after the manner of Jacques Loeb. He concluded that the fertilization of an egg and its transformation into larva was a series of successive coagulations and re-resolutions of the nucleus membrane and other parts of the egg. Thus he obtained the phenomenon of parthenogenesis in the case of the sea urchins' eggs, using acids for the dissolving and tannin for the coagulating effect. The larvæ which he obtained were transformed into minute sea urchins, and two of them developed normally. Since the time of these experiments the specimens have kept alive and showed a steady growth. One of them now has a diameter of about half an inch, counting the spines, while the second and larger one has at present 0.7 inch without counting the spines. Should they reach the adult stage, M. Delage intends to make some very interesting experiments upon the second generation of such specimens. Without leaving these researches, he is seeking for other means of producing the artificial fecundation, and now succeeds in accomplishing this by an electrical method. In a condenser formed by a sheet of mica he places as electrolyte a liquid composed of sea water to which is added a sugar solution of the same density. The condenser has the form of a trough, and the eggs placed in it are made to receive a series of electric charges. It was found that such eggs were fecundated by this means. Eggs used for a check test which were placed in a similar apparatus but without receiving an electric charge were not fecundated, and it is thus proved that the larvæ are obtained by means of the electric charge. He has secured several larvæ by this method.

CHAINS AND CHAIN MAKING.*

ITS HISTORY AND TECHNIQUE.

BY JAMES H. BAKER.

THIS paper is not intended to instruct the chain manufacturer, but will be, the writer hopes, of interest to engineers in general, and shall be gratified if the matter presented is found to contain any suggestions of value to our manufacturers. I have asked all manufacturers who, I supposed, were making something new, to send me samples and information. Some have done so and others have courteously replied that they had nothing new. In presenting these samples and discussing the information obtained, it would be very wrong to misrepresent any manufacturer, and equally wrong to give a favorable opinion of an article or process when they do not seem to warrant it.

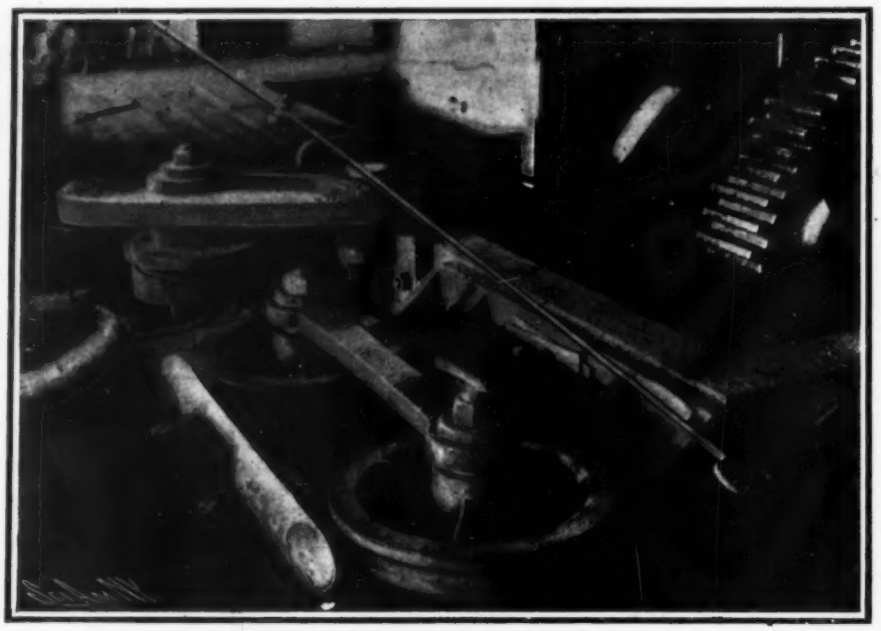
Just when chains were first made must be left in mystery, because the word has meant almost any kind of connection, as for instance, a chain of mountains. It seems that the first chains used, and that was thousands of years ago, were rings of metal fastened to cloth, thus making chain armor. Later, rings were joined together by other metal rings, and this was the first metal chain. Up to about 125 years ago there seems to be more mention of chains as ornaments than for any other purpose, although there had been an occasional patent issued as far back as 275 years.

The first patent I can find an account of was issued in England in 1634 and was described as follows:

"A way for the mearing of shipps with iron chaynes by finding out the true heating ppaeing and temping of iyron for that ppose, and that he hath nowe attayned to the true vse of the said chaynes, and that the same wil be for the great saveing of cordage and safety of shipps, and will redound to the good of our comon wealth."

More than fifty years elapsed, and in 1690 a British admiral recommended that chain moorings be introduced into the English service; but not until one hundred years ago were chains used as ships' cables. (By the way, the original meaning of the word "cable" was "capable.") For nearly a hundred years more we hear of no progress. It is interesting to note that almost every conceivable form of chain was brought forward during about one generation, from 1790 to 1820. True, there have been many new machines invented for making the different forms of chain, but even now nearly all the chain made in this country, of the welded type, is made either by hand or under very simple power hammers. There has been quite a development in wound wire or weldless chains, and electric welding has made progress within the last twenty-five years; but both these methods have, so far, only been successful in light chains. Wire-wound chains hardly run over ¼ inch, and electrically-welded, not over ½ inch.

In 1783 a patent was issued in England for making chain by casting one link in another and annealing the chain when done. Later, this method was tried under modern conditions in France, but has not been a success. Another patent, in 1791, covered a combination of metal and leather designed to prevent noise and give elasticity, prompted probably by the fact that hempen cables were noiseless and would stretch and recover a great deal. Iron chains were much objected to because they would not stretch. In 1808 the first chain was put on a vessel as a cable, and then patents in England came thick and fast. The one which probably had the most to do with furthering the use of chain cables was granted in 1808 to Samuel Brown, covering swivels and shackles. The shackles, Fig. 1, met the greatest objection directed against iron cables, which was that they could not be parted quickly, while a hempen cable could easily be cut. The pin *A*, Fig. 1, being tapered, was easily removed and then the bolt *B* could be driven out. Another patent was for a method of coating these pins with a soft, non-corrosive material. There has hardly been any change in the form of shackle since it was first patented. In this connection it should be noted that all shackles, rings, hooks, end-links, etc., should be heavier than the body of the chain; often much heavier. The shackle shown is a joining shackle. End, or anchor shackles were and are larger.



HYDRAULIC MACHINE FOR FORMING THE LINKS.

In order to meet the stretch of hempen cables, twisted links with studs in them were patented; it was claimed that a cable of these would stretch and recover 8 or 10 feet, but they never came into general use.

Side welding* was practised more or less, but not until about 1840 was it made a matter of prominence; more so as sizes increased. Side welding has fallen into disrepute with the U. S. government, which, I think, is clearly due to the method by which side welds are made. Fig. 2 shows a link, of which one-half of the lap at *A* has been welded; the link *B* is then shifted to the other end and the remaining part of the lap *C* welded. But in many cases slag imprisoned at *D* prevents a good weld being made, and the larger the diameter the more difficult it is to expel this slag by hand working. Further, large links are hard to heat properly with the cold link *B* in such close proximity. Stud chain in the largest sizes, if made as it should be, by proper machinery, would undoubtedly be the best as well as the lowest priced, and that such machinery can be devised I have no doubt. The only end-welded chain comparable to a good side-welded article is hand-welded, and that is expensive.

Stud chain as we know it, Fig. 3, was patented in 1813, and seems to be the last English patent of much consequence, though many efforts were made in the following ten years to improve chain. Studs were welded in the links, but these soon passed away, and have mostly been of cast iron. Our government now uses drop-forged studs and demands that the grooves for the links be milled. During all this time unstudded close-link chain kept pace in the manufacture and in the improvement of the iron for making it. But little has been said about close-link chain, as the interest largely centered in ships' cables. Nearly all improvements as to forms of welded chain were made in England, but we have made great progress in this country in the matter of increasing production, and

This smith and his two helpers are forging 1¼-inch ship's cable at the rate of 35 links in one hour.

THE MANUFACTURE OF CABLE BY HAND.

* A paper read before the Mechanical Section of the Engineers' Society of Western Pennsylvania, and published in their Proceedings.

* From "Chain Cables and Chains," by Thomas W. Traill. Crosby, Lockwood & Co., London.

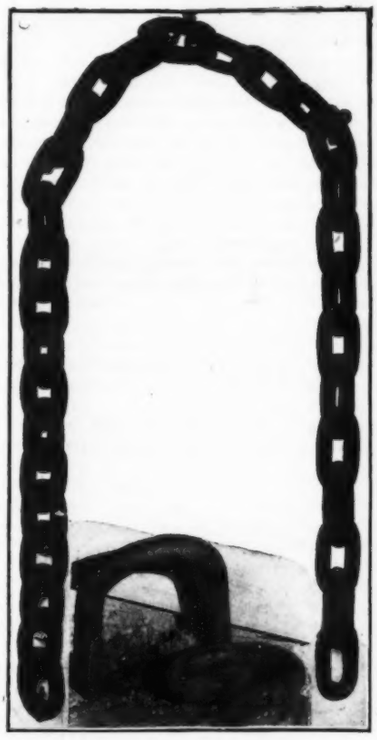
stand abreast with any in the matter of fine material for chains.

At *A*, Fig. 3, is shown a "crown" at the weld, which all fine end-welded links have, and this swell is often also sidewise; but, even with the "crown," the links will be weak at the point where the ends of the laps come, indicated by the arrow at *B*. The very best of end-welded links have the ends of the laps carried back on the sides as far as possible, say to *C*.

In 1811 an English patent was granted for winding rods into a spiral from which the links were cut. Fig. 4 shows a device which was operated by hand, working the rod hot as it came from the rolls. Fig. 5 shows a blank of half-round section which was bent twice around and welded together. Fig. 6 shows a blank made of square bar bent three times around and welded. Fig. 7 shows a Belgian method. Of these, I consider the plan shown in Fig. 6 to be the best, but this compound winding and welding at the same heat has the objection of necessitating the links to be of too great length for many purposes.

An English patent, granted in 1812, covered a form of link blanks, Fig. 8, forged with heavy parts to form the ends of the links, the purpose of which is obvious. Figs. 9 and 10 show an effort to form the studs integral with the links. Figs. 11 and 12 show links welded and looped and this is probably one of the oldest forms of chain, although at first the links were not welded. Fig. 13 shows the method practised about eighty years ago for rolling link stock so as to give extra strength at the welds. The material was rolled in the usual way to the size of the large part, was then passed through an extra set of rolls to reduce the intermediate parts, and was cut at an angle while hot. Fig. 14 shows a plan for making links from a solid bar, cutting at an angle; after cutting out central portions *EE*, the parts *AA* and *BB* are bent and welded together. This plan has been elaborately tried in other forms, such as star section, but I do not believe the idea can be made practical. It will be noted that all of the above efforts, except the Belgian and the intermediate rolling process, were made within about fourteen years from the introduction of the first iron cable in 1808.

Coming to this country, it seems a little strange that the largest chain of any length ever produced here was made about one hundred and thirty years ago, when there was not a rolling mill or steam hammer in the country. There were 500 yards of this chain, the links being made of 3½-inch squares with corners slightly rounded, and each link weighed about 275 pounds. Through the courtesy of Mr. J. G. Schmidt, president of the Standard Chain Company, I am enabled to have a sample link of this chain before you. This chain cost the colonies over $2,000 per ton, and was made for the purpose of preventing British ships ascending the upper Hudson River, the chain being held at the desired height by logs bolted together. Notwithstanding all the English enterprise, it was nearly fifty years after the production of this large



The ten links to the right stretched to the extent of two links in ten without fracture. Of the two detached links, the fractured one, a piece of commercial iron, failed in a bend of 90 deg.; the other, of special Burden iron, was bent as shown without fracture.

THE ACTION OF CHAIN IRON UNDER TEST.

chain here before that country made a chain as large even as 1½ inch, and it appears that this country has not since made as large a chain as this first one. The contract for this chain was awarded in the evening and work was commenced on it the next morning at Sterling, about twenty miles back of West Point, N. Y. Seventeen forges were engaged in the work, ten for forging proper and seven for welding.

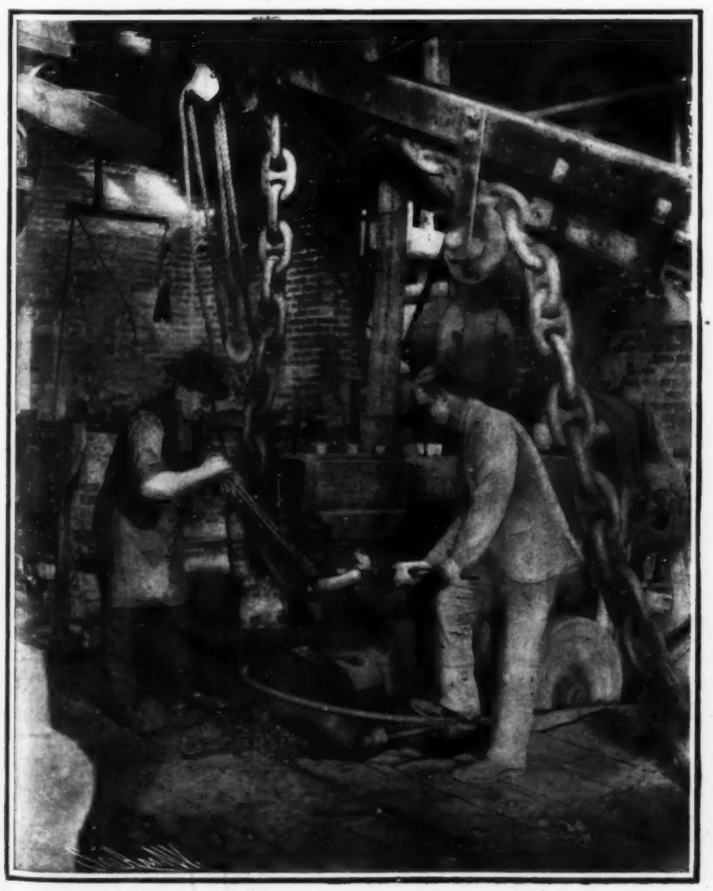
The history of chain making in this country is meager indeed, so far as records go, and there was little chain made in factories until about the time of the civil war. It seems there was a ships' cable chain works established about 1835 or 1840 in Boston, and in 1865 the Carr Chain Works was incorporated at Troy, N. Y., and became quite a factor, especially in fine chains; this company was, I believe, in some way connected with the Burden Iron Works. About the same time A. Hewitt & Co. established a works in Trenton, N. J., which also made much progress. One among the earliest manufacturers was the Hayden Chain Works at Columbus, Ohio, which started by making harness and saddlery chains. They finally engaged in making high-class crane chains, and were perhaps as great a factor as any in displacing English chain in this country. Even up to twenty years ago English chain still had a hold here, one brand, the "Lord Ward," being very popular for certain work.

I need not go into the enumeration of chain works at present in existence, but am glad to say that Pittsburg to-day is the largest producer of chains in the country, and not only stands first in production, but it is at the head in fine chain material in both iron and steel.

Many curious and some very ingenious chain-making machines have been invented, and while many patents have been issued in this country for processes such as making it automatically from the straight rod, the great bulk of all chain is hand-welded; crane chains, and in fact all chains 1¼ inch and larger, if not strictly hand-welded, are nearly so. Most of the smaller chain of the usual quality is made by coiling the links, cutting them at an angle and welding in dies. Originally, the hammers carrying the dies were mostly operated by the workman's foot, but power is being applied to these operations to an ever-increasing extent, even down to quite light chains. Men become very expert, and a good man or boy can cut 250 light links per minute while they are wound at a very rapid rate, and in light chain, an expert can weld 500 links per hour.

The heating is usually done in flat-top furnaces, the links being suspended through holes in the top of the furnace and held by rods with hooks on their ends; usually, a boy places the links on the hooks and puts them into the furnace. When one considers that the chain maker has to lift this link from the furnace with one hand, catch it with tongs in the other, thread it into the chain, place it in the dies and turn it once or twice while welding, expert chain making becomes an interesting operation.

Electric welding of chain was first tried about a



BRINGING SCARFED ENDS OF LINK TOGETHER READY FOR WELDING.

INSERTING THE STUD IN HEAVY STUD CHAIN.

CHAINS AND CHAIN MAKING.

quarter of a century ago, joining two half links, Fig. 15, at *A*. Links as large as 3-inch diameter have been made by this method, which seems to have been abandoned for large chain. Later, this plan has been successfully used, but as far as I can learn, only on small sizes. Recently electrically-welded chain up to ½ inch has been made commercially by automatically cutting the blanks from a bar so as to form a socket in one end and a corresponding taper on the other end of the link blank, Fig. 16. The blank is then bent, joined on one side and the joints welded; this obviates the usual amount of upsetting. The lap, or area of contact, is much larger than in the squarely-cut ends, and a nice-appearing and good weld is made.

Weldless chains have superior strength in the small sizes, say below ¼ inch, because the wire from which they are made, being cold-drawn, has a much greater strength than rod steel; and the smaller the chain the more difficult it is to make a weld which will be as strong as the rod from which the link is made.

All manufacturers give tables on chain, and Trail, already referred to, gives a most complete collection of tables. I have deduced some formulas I have found useful. From the nature of the case, figures as to strength of chain can only be given approximately.

DIMENSIONS OF LINKS.

Stud chain: Maximum length inside, four diameters of the bar from which it is made; maximum width inside, 60 per cent of inside maximum length.

Standard close-link: Maximum length inside, three diameters of the bar from which it is made; maximum width inside, 70 per cent of the maximum length inside.

Coil chain: This generally runs about like close-link but, if anything, somewhat longer in the links.

Crane chain: Length inside 2⅝ times the diameter of the bar from which it is made, but it varies somewhat. As a rule, the shorter the link, the better. Note.—Allowable variations under maximum dimensions may not be over four per cent, and should not be more than two per cent.

WEIGHTS.

Stud chain: 3¾ times the weight of the bar from which it is made. This includes the stud, it being equalized by the extra length of link.

Standard close-link: 3¾ times the weight of the bar from which it is made.

Coil chain: 3⅝ times the weight of the bar from which it is made.

Crane chain: 4 times the weight of the bar from which it is made. This extra weight is due to the links being somewhat shorter, and to the "crowns" on the welded ends being heavier than on common links.

BREAKING STRENGTH FOR WELL-MADE CHAIN.

Stud chain: 165 per cent of the strength of the bar from which it is made.

Standard close-link: 138 per cent of the strength of the bar from which it is made.

Coil chain: 120 per cent of the strength of the bar from which it is made.

B. B. crane chain: 145 per cent of the strength of the bar from which it is made.

It will be noted that the weight and strength run a little higher on the light sizes up to about 1 inch, as the bars from which these are made are 1/32 inch larger in diameter than the nominal size of the chain. When in light sizes the chain is made of exact size bars the chain size is given as "neat." Ordinary, or die chain, from ¼ inch down, becomes less and less in strength compared with the bar as the sizes become smaller; hence the greater strength of weldless chains in the very small sizes.

Fig. 17 shows how the sides of the links straighten at *D* and bend at *A* when the chain has been loaded sufficient to distort the links, and explains why links will not stand double the load of the bar. While the metal is stretching generally, the stretch is very much greater in the outer line at the quarter, and added to this is the fact that the ends of the laps come about at this point.

The chains of commerce have as many names as the uses to which they are put; but some terms need a word in explanation. "Proof chain" is a term applied to chain that has been pulled in a testing machine up to a certain strain. This is usually somewhat below one-half of the load it should take to break the chain. "B. chain" is an abbreviation of "best"; competition resulted in "best-best" and later "B.B.B." (3-B), so that hardly anyone now speaks of 1-B chain. Well-made chain of Swedish iron, when pulled to the breaking point, is stiff enough for a walking stick, owing to the links closing in on each other sidewise. "Dredge chain" is the same as "3-B," but should have special attention paid to the hardness of its stock to stand wear in sand and dirt. Nearly all of our common chain is now made of steel, and a good deal of it, above the common grade, is also made of this material and is giving satisfactory service. For particular purposes, especially where great safety and resistance to wear are required, special iron is keeping first place.

WEAR.

The greater the number of links in a given length, the longer the chain will wear; the greater the angle at which the links play in each other, the faster the wear, and sometimes there will be more than double the wear in one part than in another. The old style tongue chain on wagons wore much faster next to the tongue than at the horse's collar; breast chains wore faster in the center than at the ends next to the horse's shoulder, and it used to be the custom to make these chains with heavier parts accordingly.

It may be of interest to know how such chains were made, though I believe all such methods have been abandoned. The links were forged in several sizes and lengths, and pains were taken to forge the sizes somewhat unevenly. The links were then strung on a rod, Fig. 18 for tongue chains, and Fig. 19 for breast chains. After being placed on the rod according to length, each length was assorted by the eye as to diameter, thus grading them fairly well. Commencing with the first, in Fig. 18, the heaviest one was welded up full length, the next cut off a trifle at the ends, the next still shorter, and so on. The same method was pursued with the links in Fig. 19.

Chains used in critical places should be annealed at times. The principal need for this arises from strains sufficient to bend the links; this bending, being really "cold work," hardens the material. If one can be certain that a chain has had no strain over about ¼ of its proof strength, or ⅛ of its breaking load, there is little occasion for annealing. But if a chain has been strained well up to its ultimate strength, it should be annealed, even if that be every day; but there is no sense in using a chain up to this limit except in dire need.

FIG. 1

FIG. 2

FIG. 3

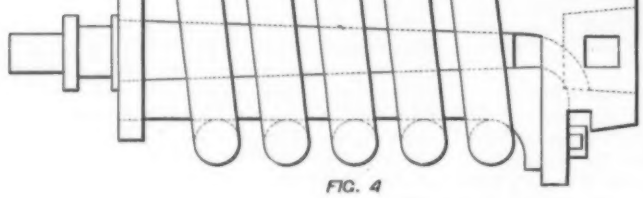


FIG. 4

FIG. 5

FIG. 6

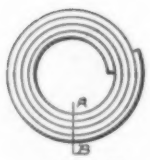


FIG. 7

FIG. 8

FIG. 9

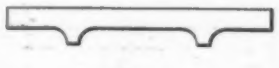


FIG. 10

FIG. 11

FIG. 12

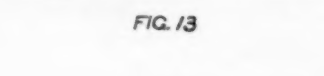


FIG. 13

FIG. 14

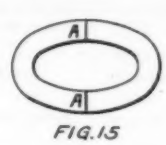


FIG. 15

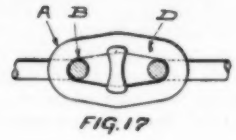


FIG. 17

FIG. 16

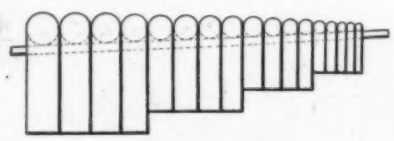


FIG. 18

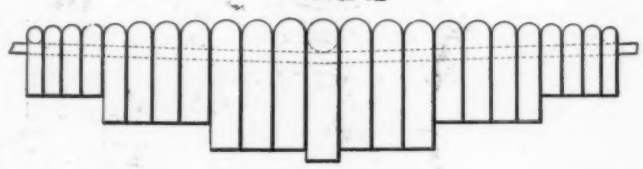


FIG. 19

RELIABILITY.

Much depends on the honesty of the manufacturer and the chain maker. Rugged honesty in the manufacturer has an influence on his workmen, because he will endeavor to employ only honest men—men who appreciate that the chains they make would be dangerous to use if not made with proper care. This may seem to be a platitude, but preference should be given at all times to men who have the best character for honesty; a good chain maker knows when he is making a doubtful weld. While all chain for important work is generally proved, proving does not tell all the story. However, users should understand that they should not expect common chain, which has a wide and useful field of its own, to equal the higher class of product required for certain purposes.

Glossy Starch (Zwick's).—Heat to melting 4 parts of wax and stearine and to the hot fluid add 1 part of ammonia, stirring meanwhile, a thick mass being thereby immediately produced. If heated further, it becomes thinly fluid again, whereupon it is diluted with 80 parts of boiling water, mixed with 400 parts of starch and poured into molds.

THE ULTIMATE INTERNAL COMBUSTION MOTOR.

ITS PROBABLE FUEL.

BY THOMAS L. WHITE.

PERHAPS the truest thing that can be said by way of a review of present practice in the design of automobile motors is that we are drawing to the close of a period of empirical construction and entering upon a period of systematic research. The principal need of the designer at the present time is for the kind of information which the steam engineer derives from his steam tables, and, speaking of the well defined field covered by the power equipment of the self-propelled vehicle, the indications are that in the present state of our knowledge no structural changes of a radical character are probable, or even possible, even in the event of a failure of the gasoline supply, and that further gains in thermal efficiency can only result from a more thorough study of the physical and chemical changes which occur in the working fluid from the moment that it enters the carbureter to the moment when it leaves the exhaust.

There is no intention in putting forward these propositions to claim finality of design for the existing type of motor nor to minimize the importance of the fuel issue. They simply represent the facts. It is significant, for instance, that although the high compression alcohol motor has a thermal efficiency of over 30 per cent, and alcohol is cheaper on the Continent than gasoline, there has been practically no attempt in France or in Germany to install this type of power plant in the automobile. It is equally significant that the Automobile Club of France is now offering a prize of 10,000 francs, not for a suitable equipment to burn alcohol, but for a "cheap fuel for general use and for a suitable device for its gasification, which must both be adaptable to all motor systems."

LIMITATIONS TO CHANGE IN ENGINE DESIGN.

The fact of the matter is that the present type of automobile motor is the outcome of a number of determining conditions of which the necessity of using gasoline was only one, and the current impression that it is the low pre-ignition temperature of gasoline and air mixtures that has prevented the use of high compressions is only partially correct. There are other reasons which are just as cogent. One of them is that the high-pressure motor is not suited for lay use. In inexperienced hands the compression is apt to be lost, owing to the piston rings and valves giving out through want of attention. Another is that the high-pressure motor is a violation of the accepted canon of automobile design that power must be sought in the direction of speed and not in the direction of weight. Still another objection, and, perhaps, the most important of all, is that it is difficult to the verge of impossibility to control the ignition of a high-speed motor under conditions of varying load, unless the quality of the mixture can be depended on to be absolutely the same at all speeds. Where the fuel is vaporized by the ingoing air this condition is rarely attainable. The same trouble is experienced with the high compression suction producer engine. Here it is the percentage of free hydrogen in the producer gas which varies with the speed of the motor, and the opinion is held by many engineers that the presence of this hydrogen, in spite of its great fuel value, is a positive disadvantage.

Engineering progress is not as a rule along the lines which are technically the most desirable, but along the lines which have been set by economic necessity, and as a reason, though not a technical one, for the conservation of the present type of motor must be reckoned the natural inertia of the existing order. This is inimical to revolutionary policies. From a business standpoint the introduction of a new fuel for use with the current equipment is a vastly better proposition than the introduction of a new type of motor to burn a new kind of fuel, no matter how good the latter may be. Also it must be remembered that gasoline will for many years be an alternative fuel. In fact, in some localities it will continue to be the only fuel obtainable, and as the automobile in its capacity as a long-distance vehicle has no fixed base of supplies, it will be necessary for it to be able to get along on gasoline on occasion, at any rate until the coming fuel is so widely used that a supply of it can always be depended on.

NEW LINES OF RESEARCH.

If, as seems to be the case, the long supremacy of gasoline, and other causes of a less ephemeral character, have left a permanent stamp on the design of the automobile motor, then it is to the chemist that we must look not only for aid in the fuel question, but also for information about the phenomena of combustion, to enable us to use the type of heat engine which we have to the best advantage. The time has come when physical and chemical research must supplement a too narrow devotion to the purely mechanical side of motor engineering. To quote Prof. Vivian B. Lewes in this connection, "The engineer relies upon his indicator diagrams and tests of horse-power for information which could be much more easily obtained by analysis of the exhaust gases, and if this method of investigation were employed important advances would very soon follow. Analyses of the exhaust gases from motor engines are remarkably scarce. Indeed, I do not know of any in this country. But Mr. Sorel, in 1903, published in France some results in which he showed that with a motor running at 1,061 revolutions per minute and using 382 grammes of gasoline per brake-horse-power-hour, the products contained unburned compounds which represented 82 per cent of the hydrogen and 42 per cent of the carbon present in the original fuel, thus reducing the heat value of the gasoline used in the cylinder from 11,278 to 5,085 calories."

Almost identically the same contention is urged by Dr. Warschauer in a recent address presented to the Association of German Chemists of Berlin. "Until now the design of vaporizers for different kinds of fuels has been determined entirely by empirical methods. Right here the assistance of the chemist is required by the automobile engineer. By systematic qualitative and quantitative gas analysis data of great value can be derived regarding the character of the combustion of fuels. To take an illustration from the field of illumination, I will quote one of the most important propositions from Stepenoff's 'Theory of the Kerosene Lamp.' It is as follows: 'The efficiency of the lamp is best determined by the analysis of the gases given off.' The same truth with a suitable change in the wording can also be applied to the explosion motor."

The analysis of the exhaust gases from the explosion motor, important though it may be, is however, only a step. It reveals the last stage of the complicated reactions which have occurred during the expansion stroke, but it affords little information as to the actual nature of these reactions or of the heat changes which accompany them. If carbon be slowly oxidized in the open air, as in the decay of wood, or almost instantly consumed behind the piston of an engine, the amount of heat liberated and the final product are the same. The difference is not in the process, but in the conditions under which it is conducted, and the final goal of the work of the chemical engineer is the determination of the how, why, and when of those factors, which in the case of the decaying wood and of the burning fuel are so widely divergent.

ACTION IN EXPLOSIVE MIXTURES.

Some of the results which are coming to light in connection with the study of the energy transformations which occur in the motor are sufficiently startling. Thus it appears that carbon monoxide is absolutely inflammable in the absence of water, and, further, the velocity with which an explosion in a mixture of this gas with air is transmitted depends on the amount of aqueous vapor present. Again, there are reasons for believing that the propagation of the flame in the cylinder of a gas engine is not by direct inflammation, but by the adiabatic compression to pre-ignition point of successive layers of the mixture. It also seems that the old belief that carbon will burn to carbon dioxide in the presence of an excess of oxygen is not altogether well founded. Under certain conditions the lower oxide is just as likely to be formed as the higher.

The fact is that the idea that during the expansion stroke of an explosion motor the carbon and hydrogen of the fuel simply burn up more or less quickly must be abandoned. What really happens is infinitely more complex. Thus every reaction which can occur in the cylinder is reversible within the temperature, pressure, and concentration limits of the cycle. Moreover, it is probable that the combustion of the mixture is far from being of a uniform character throughout its mass at any given moment. There is reason for believing that different reactions may occur simultaneously at different points of the working fluid. It is possible, for instance, that water is being formed and decomposed at the same moment during the same explosion.

Speaking of the investigations which are actually being made at the present, the determination of the rate of heat flow through the cylinder walls and the estimation of the specific heat of carbon dioxide at combustion temperatures are the subjects of recent monographs. The latter quantity is important in connection with the phenomenon of suppressed heat and in the determination of the proportion of a given quantity of hydrogen or carbon which can be oxidized under given conditions.

MIXED FUELS.

As there seems to be little doubt that the fuel which will take the place of gasoline will be a blend with an alcohol base, it is becoming important to be able to trace the effect of each individual ingredient in a mixed fuel. It may be pointed out that the properties of a blend are far from being a mere statical average of the properties of its constituents, for each admixture has a functional as well as a quantitative effect on the behavior of the whole in the motor. Thus the addition of acetylene to alcohol by accelerating its combustion in the motor increases its efficiency. Lastly, it may be mentioned that the increase of the calorific value of a fuel by blending has no effect on the specific power of the motor in which it is burned. The maximum power of a given motor is independent of the calorific value of the fuel which is used in it, the popular belief to the contrary notwithstanding.—Iron Age.

SALT GLAZING.

SALT glazing is applied only to low grades of earthenware. Common salt is employed, not only because it is the cheapest form of soda, but also because it is volatilized at a low temperature, about 1,650 deg. F. The furnace is regulated to give a reducing flame, the effect of which is to reduce the oxide of iron in the clay. The salt is then thrown into the furnace where, under the influence of heat, it reacts with the water vapor which is always present, forming caustic soda and hydrochloric acid. The soda then combines with the silica of the clay, producing sodium silicate, which fuses and forms a glaze, the color of which is brown with an oxidizing flame, gray with a reducing flame, and greenish gray with a very smoky flame.

The formation of bubbles in the glaze is due to the presence of sulphate of lime in the clay and the employment of too high a temperature. The sulphate of lime is decomposed by the carbon of the fuel, forming sulphuric acid and carbon monoxide. If the temperature does not exceed 1,650 deg. F. the clay remains porous and allows these gases to escape, but if the clay is heated above 2,000 deg. F. it loses its porosity and retains the gases in the form of bubbles. If the surface of the glaze shows a slight roughness, resembling that of an egg shell, the glaze has not been completely fused. This may be due either to too low a temperature or to a deficiency of salt. In other cases the glaze, though glossy at first, becomes dull in a few hours. This result is due to too rapid decomposition of the salt. The acid vapors are driven off too quickly and completely so that the alkaline vapors which the glaze evolves in cooling are not neutralized and tarnish the surface.

So much time and care are expended by manufacturers in turning out well-painted and beautifully trimmed cars that it is bad management not to give more attention to their washing and polishing. There are at least fourteen coats of paint on the average body; the leather is of the finest machine-buffed or hand-buffed quality, and the best grade of curled hair is used in upholstering. Yet the owner or user knows little or nothing about cleaning and dressing a car. Linseed oil is the life of all paint, and soap made from it retains enough of its properties to act as a preservative of paint and varnished surfaces. The soap must be made by a special process; it must be strictly neutral, and contain not even the slightest percentage of free alkali. Alkali attacks paint and varnish as soon as it comes into contact. A perfect soap is one in which a chemist cannot detect even the slightest trace of alkali. It must be free from rosin or any other harsh or gritty substance liable to do injury to the finish. Properly made, it is soft and transparent, a little heavier in consistency than vaseline. Such a soap acts as a solvent, and removes the dirt, grease, and grime by carrying it off in a thick heavy suds. Another excellent soap is made from green oil, and is used particularly in washing off the oil from a car. It does not harm the finish in the least. A raw soap standing on varnished surfaces has a tendency to soften the varnish if allowed to remain too long. Consequently, soap should be thoroughly dissolved before washing the car. If the vehicle is dusty, and the suds should fly onto the dry dust and be allowed to stay, they will spot the body. But if the car has first been gone over with the hose, the suds have no effect on the varnish.

CHÉRON'S SYSTEM OF COLOR PHOTOGRAPHY.

THE USE OF MINUTE SPECTRA FORMED BY PRISMS.

BY OUR PARIS CORRESPONDENT.

AN interesting process of color photography has been brought out by M. André Chéron, of Paris, and he has been successful in reproducing very nearly the natural colors of different objects. In Germany, Dr. Julius Rheinberg, and in France Prof. Lippmann have been working independently, in theory at least, upon the same idea, namely, the use of minute spectra formed by a prism, but M. Chéron seems to be the first to have obtained any practical results in the production of colored images. In the present process the image of the object photographed is focused on a screen *T*, Fig. 1, which is made of a clear plate glass having a large number of fine opaque parallel lines engraved upon it and separated by transparent intervals about four or five times narrower than the opaque lines. Hence the rays forming the image are partly stopped by the opaque lines and can only go through by the transparent intervals. Seen from the rear side, this image will appear to be separated into a series of lines separated by black spaces. Back of the image is a lens *L* which serves to concentrate the rays. We may take the case following in order to simplify the action. Consider four of the clear spaces of the screen, *a*, *b*, *c*, *d*, and that these spaces are illuminated each

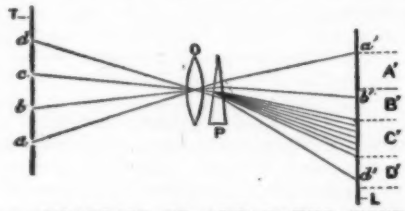


FIG. 1.—DIAGRAM OF APPARATUS USED IN M. CHÉRON'S SYSTEM OF COLOR PHOTOGRAPHY.

with a different colored light, *a* receives red light coming from the left-hand side, while *b* receives yellow rays, *d* blue rays, and *c* is lighted by white light. Back of the screen is placed a lens, *O*, and prism, *P*. The prism is constructed so as to give a very small angle and is in fact almost plane. Each of the rays coming from *a b c d* will therefore go through the prism and be dispersed upon a screen which is placed on the right, and each of the original rays, after passing through the prism, will occupy a corresponding position upon the screen. If the ray is white, as in the case of the space *c*, the prism will cause it to give a

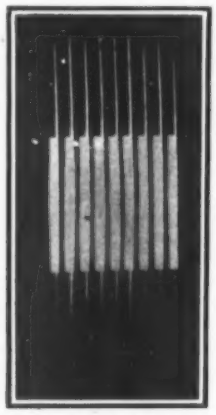


FIG. 2.—SPECTRA FORMED BY THE ORIGINAL SCREEN.

FIG. 3.—FLOWER REPRODUCED WITH THE ORIGINAL SCREEN.

complete spectrum which is, however, very narrow, owing to the small angle of the prism. This spectrum occupies the space *C* upon the screen. Should the original lighting be monochromatic, as for the other bands we are considering, the ray will pass through the prism without any dispersion, but will simply be deflected, and will fall into the corresponding spaces *A'*, *B'*, *D'*. The relative position of the band with reference to its space will naturally depend upon the color, and thus *a* being red will lie near the top of the space *A* while the blue ray *d* will lie toward the bottom. In short, all the transparent intervals of the screen, and in consequence all the lines of the visible image which it receives, in place of forming equivalent lines upon the screen *L* or upon a photographic plate placed here, will give the corresponding spectra of these lines owing to the use of the prism. The distance between the transparent intervals of the screen, the thickness of the black lines and the angle of the prism are naturally calculated so that the spectra which are formed on the plate *L* are exactly juxtaposed but without interfering with each other, so as to avoid any confusion in the colors. Each point of the image forms, therefore, a complete spectrum if it is white or in the space occupied by a spectrum there is a point which corresponds exactly with the refracting angle of a certain color, if it is simple, or if it is composite, of a set of points or portions of a spectrum in each one of the spaces *A' B' C'*, etc.

If we place a photographic plate in the plane of the

FIG. 4.—PORTRAIT PRODUCED BY M. CHÉRON'S SYSTEM.

FIG. 5.—A VASE OF FLOWERS AS REPRODUCED IN COLORS.

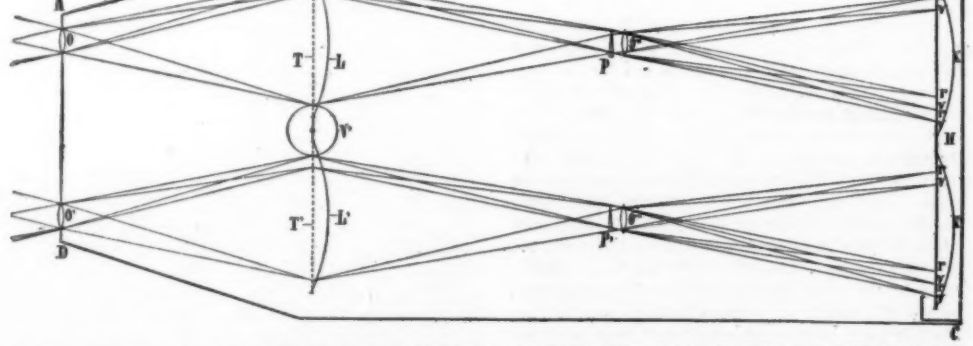


FIG. 6.—DIAGRAM OF A NEW STEREOSCOPIC APPARATUS NOW BEING CONSTRUCTED BY M. CHÉRON.

different place corresponding to its angle of refraction, as above remarked. Such an image will, of course, be simply in black and white. Then we make a positive plate from the negative, in which case the parts of the negative which were acted upon become transparent in the positive, while the others are black and opaque. Thus the positive is transparent at *a'*, *b'*, *d'*, and in the whole of the space *C'*.

If we replace the positive plate in the apparatus at *L* and now illuminate the screen *T* uniformly with white light, in the first place, on the plane of *L* we will have a series of complete spectra coming from each of the white bands of the screen *T* and the spectra are formed upon *L*. But now the whole of these spectra are complete, and *L* is covered with a series of spectra like *C'* in all the spaces *A'*, *B'*, *D'*, seeing that each ray coming from *T* is now white. On a ground glass screen placed at *L* and seen through a magnifying glass we would observe a continuous succession of very narrow spectra, but as the positive plate occupies this point, the opaque parts of this plate screen off the spectra wholly or in part, while the transparent portions let the light through. However, the transparent parts of the positive are equivalent to the parts of the negative acted on by the light, and correspond to the angle of refraction of the color which fell on the negative at this point, therefore the transparent part of the positive, at *a'* for instance, will let through the ray *a'* of the complete spectrum *A'* and no other color can be seen from the right in the space *A'*. The white parts which in the first case gave complete spectra as at *C'* upon the negative will give entirely transparent portions on the positive and thus we will see the entire spectrum from the right, but as this is very narrow it will give the impression of white when seen at a short distance, owing to the mingling of the colors. A partial spectrum in one of the spaces will give the corresponding color of the original from the combination of the rays in the same way as for the white, while the opaque parts of the original will give corresponding black parts, since the negative has not been acted upon. They will appear black upon the positive, and stop off the light, or else we will have gray parts which give the shades.

In the first experiments which M. Chéron made he used a rudimentary screen made by ruling lines upon a mirror by scraping off the coating from the back. The lines were about one millimeter thick (0.04 inch) and were spaced four millimeters apart. Against it he applied three pieces of colored glass laid across it, having a red glass at the top, a green glass at the bottom and leaving an uncovered space in the center. The result will be seen in Fig. 2, and the middle spaces having given complete spectra are seen as transparent or practically so, while above the red ray is shown to the right and the green ray is less deflected at the bottom part. Then he placed pieces of colored gelatine on the ruled screen so as to form a red iris flower (Fig. 3), a green leaf and stem, a yellow leaf, and a blue butterfly. Next he wished to reproduce a portrait, and succeeded in doing so. Here he used a screen ruled in black lines of 5/30 millimeter separated by black spaces of 1/30 millimeter. In this way he secured some very interesting results, and when viewed from the rear of the apparatus the positive plate formed as above, which is black as usual and appears to be ruled with fine vertical lines, gives in reality a colored image. Such a positive, which we show in Figs. 4 and 5, is really made up as we have stated of the impressions of whole or parts of spectra.

As it is difficult to place the positive plate in exactly the same position as was occupied by the negative in the apparatus, it is best to use two micrometer screens, one for placing the lines exactly vertical and the second for displacing the plate forward and back, when it is easy to bring the positive to the right place. As soon as this happens, the image is seen in very nearly the natural colors, as the writer had occasion to observe, and the effect is very striking. M. Chéron is constructing a new apparatus by which he expects to secure better results in the reproduction of the colors, as the present one is merely experimental, and he will use the stereoscopic method, as shown in Fig. 6. Here the image of an object is thrown on the ruled screen T by the lens O. A second lens L, prism P, and lens O'' are used to form the image on the photographic plate at BC. Two such combinations are placed together so as to make a stereoscopic image. An improvement will be to have one screen ruled with vertical and the second with horizontal lines, so that the stereoscopic image will have the effect of a halftone.

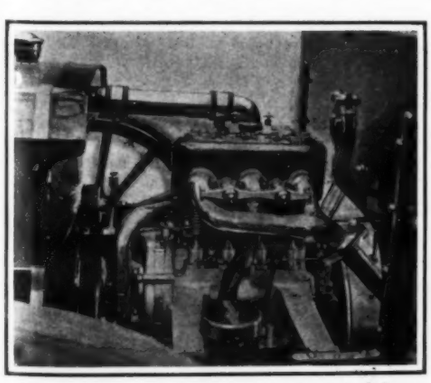
THE ELEVENTH PARIS AUTOMOBILE SALON.

GENERAL TENDENCIES OF CONSTRUCTION FOR 1909, WITH PARTICULARS OF SOME OF THE MOST NOTABLE MODELS EXHIBITED.

ALTHOUGH distinct mechanical novelty was not expected, and indeed was not to be found at the Paris Salon except in a few special cases, there was no lack of interest from a mechanical standpoint. The show was distinctly one of simplification, of refinement in detail, and of small cars. Very few constructors presented new models—models redesigned from the cylinders to the grease cups—but not a single constructor failed to show interesting improvements on his standard lines of production. The cry for something new, for novelty in design, is a common but a mistaken one. It must be some satisfaction to an owner to realize that after a year's experiments and testing the constructor decided to remain true to the same design, while giving many finishing touches to the machine which tended to make it easier to drive and maintain and indirectly to lengthen its life.

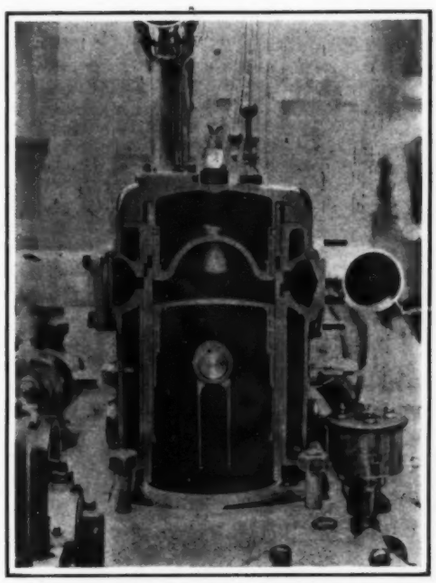
No single part of the car has been neglected in the search for simplification. On the engine the most noticeable feature is the abandonment of low-tension ignition in favor of high-tension, the change being made not because of any inherent defect in the low-tension system, but because it requires a certain amount of care that the average driver is not willing or capable of giving. Not a single example of low-tension ignition was to be found on small cars, its only application being to large cars, which are usually handled by skilled mechanics. Among the firms who have made the change from low to high tension are Berliet, Mors, Lorraine-Dietrich, Brasier, Itala, Fiat, and Mercedes. It was noticed, too, that in the majority of cases no provision was made for fitting a duplicate ignition, experience having shown that there is really no more necessity for carrying a spare ignition system than there is for carrying a spare engine or extra gear box. It is only a matter of time before a dual ignition on ordinary touring cars will be an anomaly.

Block casting of the cylinders has made considerable progress, and has contributed much toward the simplification of engines. All the two-cylinder engines are in one piece, a large proportion of the fours are in one unit, and in one case—a Delaunay-Belleville—a six-cylinder engine had been produced in one casting. One of the most interesting pieces of work in the whole show was a four-cylinder Bayard-Clement



THE NEW PANHARD 2-CYLINDER 10-HORSE-POWER TAXICAB ENGINE.

engine of about 65 millimeters bore, with cylinders and upper portion of crankcase in one piece. Naturally the crankshaft was attached to the upper portion of the engine casting, and as the lower portion had only to be used as an oil reservoir, it was formed of a piece of sheet metal held in position by screws along each side, and drawn tight at each end by encircling bands. For a small engine the idea is excellent, for it gives a more compact and neater engine, decreased weight, and lowering cost of production. The casting,



CROSS SECTION OF CYLINDER OF KNIGHT ENGINE AS USED ON THE MINERVA CARS.

In this new type of 4-cycle engine sliding sleeves with ports replace the poppet valves ordinarily used.

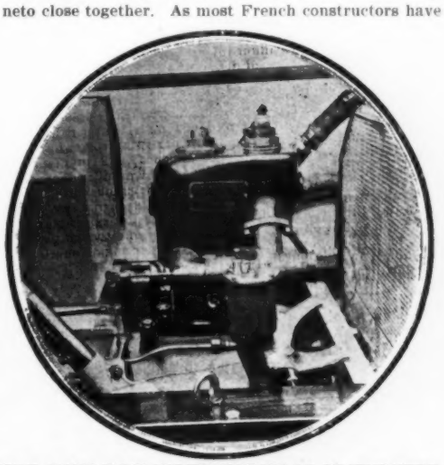
however, as can be readily understood, is not of the easiest, and would have been impossible a few years ago.

Nothing is more remarkable than the number of cases in which the intake and exhaust manifolds were cast integral with the engines, in the manner which was first introduced, we believe, by Darracq. To mention but a few, we have the Darracq, Charron, Berliet, Hotchkiss, and Delahaye.

Complicated lengths of water, gas, and exhaust piping are now an exception, and a notable feature of the Salon is the bold move toward the simplification of the intake piping. Thus, on the new Charron two- and four-cylinder models the intake has been reduced to a six-inch length of copper piping attached by one screw only. The pipe is screwed into the mixing chamber attached to the intake manifold and descends directly over the vertical carbureter nozzle, the end of the tube being bell-mouthed. The ordinary air inlet is at the base of the nozzle, and additional air is taken into the mixing chamber through three automatic valves of different size. Panhard had an interesting feature in a six-cylinder engine with cylinders cast separately but fitting close together with rubber joints, and held together by four horizontal bolts passing right through the water circulating space. The result was all the advantages of a single casting without the disadvantage of great overall area and complicated piping. The water system, for instance, called for but two lengths of pipe, one to the upper and the other to the lower portion of the radiator.

In previous shows there has been a considerable amount of ingenuity to provide a correct arrangement of the intake pipes for multiple cylinder engines in order to assure the same amount of gas to all the units. This year the tendency is to link up direct with the intake manifold a single length of pipe feeding all the cylinders. There was an excellent example of this on one of the six-cylinder Bayard-Clement engines, the single pipe curving up gently from the carbureter at the forward end of the engine, and running the full length of the engine. Experience has shown that there is no starving of the cylinders farthest removed from the carbureter, and thus the arrangement, which has the very important advantage of materially simplifying the engine, is likely to be widely adopted. There was a neat arrangement on the Delahaye models, the intake pipe being led up direct from the carbureter to the cylinders without any branches or any curves. Thus though water intake and exhaust were on one side, the engine was remarkably clean cut. Another distinctive feature on the Delahaye was the closing up of the valve springs by means of a metal plate; a similar device, differing only in the method of fastening, was shown on the Leon Bollée and Mutel models.

Thermo-syphon water circulation was more prominent than ever, and was found on probably nine-tenths of the small cars. There was a tendency, also, to place the radiator on the dashboard, in the manner inaugurated by Renault. Generally it is impossible to make a change of this nature without altering the entire design of the car, and though there were more dashboard radiators than ever before, they were all shown on new cars. The new two-cylinder Berliet had a radiator of this type, composed of plain copper tubes; the Charron had a gilled tube dashboard radiator with a belt-driven fan in the center for the four-cylinder models. Several newcomers also placed the radiator behind the engine. It is now the general rule to place the magneto and the carbureter on opposite sides of the engine. Constructors have been forced to this step by the London regulations regarding taxicabs, Scotland Yard refusing to pass any vehicle for taxicab service which carries its carbureter and magneto close together. As most French constructors have



THE SINGLE-CYLINDER MOTOBLOC VOITURETTE ENGINE.

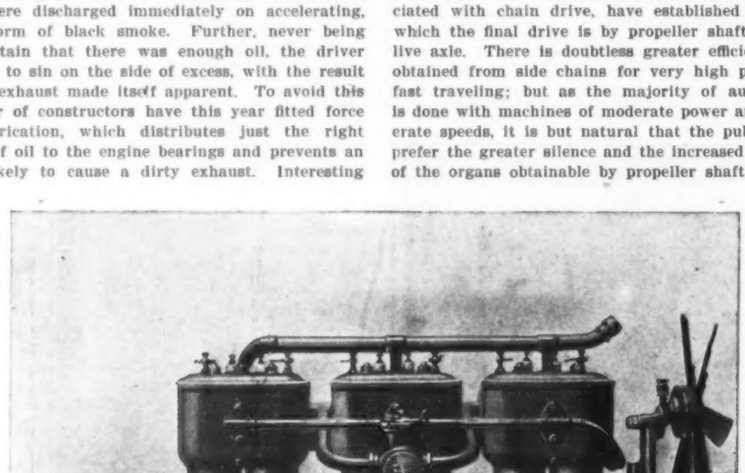
This engine is notable since its crankcase and the gear box of the car form a unit.

some interest in the London trade, they have been obliged to modify their cars to suit this regulation.

The most common valve arrangement on touring models is for the valves to be placed in outstanding ports on one side of the engine only, and to be operated by a single camshaft carried in the crankcase,

Overhead valves placed in the cylinder head and operated by rocker arms, have somewhat increased in number, but are by no means general. One of the most important examples in this class is the Pipe, with valves placed at an angle of 45 deg., and hemispheric combustion chambers. Although this arrangement produces greater engine efficiency, it has the disadvantage of necessitating lubrication with the oil can, an operation that is not looked upon with favor at a time when the tendency is to make everything automatic. An interesting example of overhead valves was shown on a small Martini, both inlets and exhausts being in the cylinder heads and operated by a vertical spindle and bevel gears from the crankshaft, the valve operating mechanism running down the center of the engine. Mechanical lubrication was provided for all the valve operating mechanism, and the whole was covered by an easily removed inspection plate.

Lubrication has received very close attention, more especially on the small cars used considerably for town service. The Paris regulation against smoky exhaust is responsible for a greater influence on automobile lubrication than is generally realized. Under splash lubrication only, the tendency was for the engine to suck up quantities of oil on being slowed down, which were discharged immediately on accelerating, in the form of black smoke. Further, never being quite certain that there was enough oil, the driver preferred to sin on the side of excess, with the result that the exhaust made itself apparent. To avoid this a number of constructors have this year fitted force feed lubrication, which distributes just the right amount of oil to the engine bearings and prevents an excess likely to cause a dirty exhaust. Interesting



A TYPICAL FRENCH 6-CYLINDER ENGINE.

This Delaunay-Belleville motor has gear-driven fan, magneto, and pump on a crankshaft in front and all the other features of the best 1909 motors.

examples of this were seen on the Berliet models. Lubricators fed by pressure from the exhaust of the engine have almost all been abandoned in favor of a positive drive by belt or, more commonly, by direct gearing.

A feature that struck even the most casual observer was the simplification of the dashboard of all the cars on exhibit. Instead of a mass of indicators, lubricator, coil, etc., the smartest cars now carry but a small sight feed and a switch. There was a very neat arrangement on the Renault models, where the lubricator had been removed to the front of the dashboard, the sight feed, with a neat glass front, being let in flush with the board. The only other object on the board was the small lever for regulating the amount of gas. The same clearing had taken place on the Panhard, the high-tension coil of the Eiseman magneto now being carried under the bonnet, on the left-hand side of the engine, the only things on the dashboard being a small sight feed and a switch. On the Berliet there was not even a sight feed, the feeds being on the front of the dashboard, and only showing that oil was flowing to the gear box and differential gear. In the dashboard was a vertical oil level, which showed to the driver what quantity of oil was available in the bottom of the crankcase for the lubrication of the engine. On the new Charron two- and four-cylinder models there was a similar dashboard simplicity, the articles being a double sight feed and a short lever which controlled the quantity of gas and, when carried over to a certain position, acted as a switch.

On all small cars the leather-faced cone clutch reigned supreme, its simplicity making it undoubtedly the best for this class of work. For higher powered vehicles, however, the multiple disk clutch was in the majority, though there were some notable exceptions in the case of Renault, Bollée, and others, where the cone was employed for very large engines. In this section the changes are in the direction of greater accessibility and ease of dismounting the organ. In transmission gears the general rule was to employ the straight through, or progressive, type of gear for small cars and the selective type with gate change for the larger models. The selective type, which allows an easier change than is generally possible on the straight through type, has the further advantage of giving a more compact and stronger box. In a large number of cases where a straight through type of gear was used it was of the "self-finding" type, the sliding gear being automatically stopped as soon as it was properly engaged, whether the driver released the clip on the end of the side lever or not.

Shaft-driven cars were much more numerous than ever before, partly because of the greater attention paid to small cars, but also owing to the conversion of a large number of constructors from chain to shaft for comparatively large models. Even such firms as Mercedes, Fiat, Panhard, and Bollée, generally associated with chain drive, have established models in which the final drive is by propeller shaft to a rear live axle. There is doubtless greater efficiency to be obtained from side chains for very high powers and fast traveling; but as the majority of automobiling is done with machines of moderate power and at moderate speeds, it is but natural that the public should prefer the greater silence and the increased protection of the organs obtainable by propeller shaft.

The tendency is to get away from the use of a torque stay or distance rods, or, where a torque stay is employed, to combine it with the housing of the propeller shaft. There was an example on one of the high-powered Renaults where neither torque nor distance rods were used; the same applies to the voiturette produced by this firm. On the Delahaye there was a neat example of the distance rods being connected up at the fore end to the same hanger as the forward end of the rear spring.

Suspension this year is almost entirely by three-quarter elliptics at the rear, with semi-elliptics in front. The platform type of rear suspension has almost disappeared from view, while full elliptics are but rarely met with. The only types finding any favor are the three-quarter and semi-elliptics.

A predominating feature of the show was the attention which had been paid to the development of small two-cylinder vehicles. Obviously these models are the outcome of the boom of the taxicab. The remarkable work done by certain constructors in two-cylinder cabs operating in all weathers and handled by men of very little experience, has led automobile builders as a whole to turn their attention to this type of vehicle, not merely for cab service, but also for pleasure and utility use. Whereas last year the small car was, with a few exceptions, the product of small firms, this season it is such large and well known firms as Brasier, Charron, Panhard, Dietrich, and Berliet that have produced models of 8-10 horse-power. Though there is a certain similarity in general lines of construction, there is plenty of diversity in detail. In all cases the engines are in a single casting; have valves on one side, mechanically operated; high-tension magneto; automatic carbureter; thermo-syphon water circulation; cone clutch; generally three speeds; and final drive by propeller shaft to live rear axle. These models could be more correctly classed in the small car than the voiturette class, for they are generally a reduction and simplification of the large car. With but few exceptions leading constructors have not tackled the single-cylinder car, the exceptions being Bayard-Clement and Motobloc. The former firm has an exceedingly interesting little vehicle with a vertical engine of 100 by 110 millimeters (3.93 x 4.33 inches) bore and stroke, mechanically operated valves, and high tension magneto. Externally the radiator had the appearance of the honeycomb type; closer examination revealed, however, that it was composed of plain vertical tubes, faced by a metal grid which has the effect of breaking up the current of air as it rushes through, thus assuring a better cooling of the tubes. A cone clutch was employed; the three speeds were obtained by a straight through quadrant, the pinions always being in mesh. Final drive was by propeller shaft. The little car was fitted with a two-seated body.

The Motobloc model was distinctive by reason of the cylinder base and gearbox being in one unit, this being, we believe, the first time that a single-cylinder car has been built on this principle. A honeycomb radiator was fitted in hinges on the side members, with provision for lubrication, thus protecting the tubes against breakage by reason of the bending of the frame on rough roads. A metallic disk clutch was employed, the gear set gave three speeds forward and reverse, and the final drive was by shaft.

Six-cylinder models have considerably increased in number, and, what is more remarkable, were presented in all powers from 16 to 60 horse-power. Two years ago there were but four models at the Paris show; this year no fewer than 98 were exhibited, of which number 70 were shown complete on cars. The smallest of the six-cylinder models was a Delaunay-Belleville of 72 by 105 millimeters (2.834 x 4.133 inches) bore and stroke, and rated at 10 horse-power. The cylinders of this model were in a single casting, this being the only case of this type of construction at the show. In the vast majority of cases the arrangement of the cylinders was in three groups of two; engines with two groups of three and with the cylinders cast separately were in about equal proportion. Panhard-Levassor presented two six-cylinder models, on one of which the cylinders were cast separately, but united so as to avoid the use of any connecting water piping, the water jackets fitting flush and being held together by four bolts passing through from one end of the engine to the other. In a number of cases an attempt had been made to reduce the overall length of the engine with remarkably good results. On one of the Mors models the rearmost cylinder had been carried under the footboard with this object in view.

High-tension ignition predominated on the six-cylinder models, the only firms employing low-tension ignition being Mors, Itala, Cottin-Desgouttes, Berliet, and Brasier. The most general order of firing was 1, 5, 3, 6, 2, 4.

Distinct departures from standard types of design were not numerous. Among those which attracted particular attention were the two Knight* engines exhibited on the Minerva and G. E. M. stands, the former firm showing a split section of a cylinder which did more to explain the working of the double sliding sleeve than any amount of literature on the subject. The G. E. M. engine was one obtained from the English Daimler factory and fitted to the Puteaux firm's gasoline-electric chassis. Panhard, who has bought the Knight patents for France, did not exhibit a model on these lines.

Hanriot & Co. exposed an interesting type of planetary transmission contained within the flywheel. On the same stand was a thermo-syphon water circulation without radiator, the cooling water being contained in a dashboard tank. Two air-cooled models were also shown, both with lateral fans, driven in one case by belt from a pulley worked off the camshaft, and in the other by a vertical spindle and bevel gears. The only eight-cylinder car in the show was presented by the E. N. V. Company, the cylinders being placed in V arrangement, cast separately, and fitted with copper water jackets. A peculiarity of this car was that the third and fourth speeds were combined with the differential gear on the rear axle, the first and second and

* The cross-sectional photograph of the Minerva-Knight engine is shown in one of our illustrations. This type of motor is the invention of Mr. Charles Y. Knight, of Chicago, Ill., and it is claimed to have several distinct advantages over the usual poppet-valve type. The two sliding sleeves between the piston and the cylinder (which are operated by connecting-rods and a small crankshaft at one side of the crank case) are noiseless in their operation, with the result that in America the engine is called the "Silent Knight." This type of valve—a sliding sleeve with ports—is much easier to keep cool and tight on a large engine, as since the water jacket can be carried all around the rectangular ports in the cylinder wall, there is no overheating and warping of the exhaust valve. The principal drawback seems to be the proper lubrication of the sliding sleeves.—EDITOR.

the reverse gears being carried in a gear box midway between the clutch and the rear axle.

The British motor car industry was represented at the Paris Salon by the Siddeley firm only, a very complete set of cars, chassis, and separate engine being exposed. The models included a two-cylinder 10-horse-power car with both long and short chassis; the former having a dropped and the latter a straight frame; a four-cylinder 14-horse-power model; a similar model with 18-horse-power engine and pump water circulation; two large four-cylinder models of respectively 30- and 40-horse-power; and two six-cylinder cars, one rated at 20 and the other at 50 horse-power. All were shaft driven with the exception of the large four and the large six.—Automobilia.

PROTECTIVE MIMICRY IN BIRD LIFE.*

A SPECIFIC INSTANCE OF ADAPTATION.

BY H. B. MACPHERSON.

THOSE who have studied the works of Darwin and other investigators of the theory of evolution cannot fail to have noted the importance attached by these writers to the laws of natural selection and the survival of the fittest. The evolution of species is a subject which could not be adequately dealt with in the course of this article, and I propose merely to briefly discuss the means by which many of the most interesting species of British birds are assisted by Nature in the great struggle for existence which is being continually waged in the animal kingdom.

Before proceeding to notice the marvelous adaptation of the coloring of the plumage of many species to their surroundings, and of the eggs of others to the situation of the nest, it will be necessary to review the dangers to neutralize which the precautions have become essential. There are few species of birds resident in these islands which, at some stage of their existence, are not exposed to risks which may prove fatal, and the vast majority have to contend with their more rapacious brethren and with their subtler four-footed enemies from the beginning of their career till the end of their life. To this rule the larger birds of prey are the sole exceptions—the eagles, the osprey, the kite, peregrine, and others of their kind. The situation of their nests and their reputation for valor serve to render them immune from attack; their sole foe is man, and no mere bird or beast ventures to approach their eyries. The lesser hawks are by no means equally secure. The hooded crow will suck the eggs of the kestrel and the sparrow-hawk during the temporary absence of the adult birds, though short shrift awaits the intruder if he is detected in the act. The eggs of the merlin are equally exposed to danger, and a stoat will devour the young hawks as readily as he would a grouse's chick. Battles in the air between hawks and hooded crows are of common occurrence, and the lightning swoops of the former generally put their slower and clumsier foes to flight.

Adult birds, with the exception of the larger predatory species and a few others, such as swans and cormorants, whose mere size is a sufficient guarantee of their safety, have to contend with prowling four-footed enemies, such as the weasel tribe and the cat species, in addition to the feathered foes of which brief mention has been made. Their eggs are tasty morsels for the egg-sucking species; hedgehogs, crows, and magpies are all equally skillful in locating the nests of our larger birds—such of these, at least, as are placed on the ground level. The hedgehog works systematically, seldom abstracting more than a single egg on the same night, but returning again for another feast. The feathered egg suckers often break and partially devour the whole clutch at a sitting. The young of all species, when hatched, are exposed to the attacks of the fox, the marten, the polecat, the stoat, and the weasel, and among broods of tender age feathered marauders play terrible havoc. Such are briefly a few of the perils which meet defenseless birds at every stage of their existence. It may be said that predatory birds and beasts are now comparatively scarce, but we must remember that game preservation alone is responsible for this fact. During the long ages which preceded the appearance of the game preserver the increase of prolific species was kept within reasonable bounds only by the attacks of their natural enemies, and it was quite in accordance with the laws of Nature that some means of concealment as protection should be devised for otherwise helpless birds. The solution lay in protective mimicry and in the assumption of plumage which resembled the surroundings of the individual.

Predatory birds and animals being so numerous, it is plain that the more striking the colors of the victims, the more readily would they attract the attention of their enemies. Thus, through the survival of individuals of sober and less striking hues, a large proportion of northern species gradually assumed the drab-colored garb which they wear at the present day.

Perhaps the most striking example of protective mimicry is to be found in the contrast between the plumage of male and female birds. The coloring of eggs to match their surroundings is another hardly less conspicuous, and the fact that young birds of both sexes almost invariably resemble the female in plumage can be explained by a similar course of reasoning. As a rule young birds are helpless, and if the young males immediately developed gaudy hues, they would fall a prey to the nearest marauder. After the first molt Nature considers that they have reached maturity, and must shift for themselves and take their chance with the rest. During the courting season the cock birds generally assume their most brilliant plumage, while their mates retain their more sober hues. Black game, wild ducks, and pheasants are good examples of this fact. The greyhen and the red grouse, sitting on their nests in heather, dead bracken, and rough grass, match their surroundings to perfection, and the crouching form of the mother bird could scarcely be detected by even the lynx-eyed falcon hovering overhead. It is noticeable that hen birds at all seasons are less timid than the males, mainly because the former hope to escape observation, while the latter are well aware that their only hope lies in instant departure.

It would almost seem that birds know instinctively whether their eggs are conspicuous objects to the egg-stealing hoodie or carrion crow. Thus we find the wild duck covering her eggs with the utmost care as soon as each has been laid and her example is followed by the red grouse and the greyhen. Generally speaking, birds which lay a considerable number of eggs before incubation commences take more trouble to conceal them than those which lay two, three, or four, as the case may be. This applies equally to the smaller species—the large clutches of the wrens and the tits are also carefully hidden from view. A large number of eggs is obviously more conspicuous than a few would be, and a longer period elapses between the laying of the first and the last eggs of the clutch in the former than in the latter case. Danger is thus increased, but corresponding care is taken to avoid the peril.

Woodcock, nesting in covert or in deep herbage, take little trouble to conceal their eggs, being well aware that the coloring of the latter renders such precautions needless; they match their surroundings as closely as the female resembles the dead leaves, bracken, or heather in which the nest is placed.

Eggs laid in the open on the ground level are, generally speaking, so marked as to avoid attracting notice, while birds which nest in trees lay eggs of brilliant hues and startling contrasts. The reason is obvious, for in the former case the clutch is in full view of the egg-sucking fraternity, while in the latter the foliage helps to conceal the nest. The similarity of the eggs of the many species of waders and shore-birds must have attracted the notice of every observer, a neutral background marked with dark blotches and streaks being the chief characteristics of those of the plover, redshanks, gulls, sandpipers, snipe, curlew, and many others. In the dark bog or moorland this type of coloring can hardly be surpassed, and such differences as exist lie in the shape, size, and shade of the background or blotches. The eggs of the oyster-catcher can scarcely be distinguished from the pebbles and shingle in which they are laid, though the same eggs, if deposited in less suitable situations, would be remarkably conspicuous. Birds which lay pure white eggs, which would be extremely noticeable if deposited in the open, are generally careful to make their nests in holes or in trees. Owls, kingfishers, swifts, woodpeckers and pigeons all follow this rule; the dabchick is apparently an exception, but in this case the nest is generally impregnable owing to its situation on the water. Innumerable examples of the laws of protective mimicry might be mentioned, but the foregoing will serve to illustrate my remarks. In some cases the eggs, being conspicuous, must be hidden by the cunning of the parent birds, in others the coloring is in itself a sufficient guarantee of their safety. I have ventured to suggest that birds are themselves aware of the effect of the coloring of their plumage. Otherwise it is hard to account for the cunning of the old blackcock or the wiliness of the mallard drake. That woodcock as a rule crouch at the approach of a foe and rise at the sportsman's feet is a fact which supports this theory. Through long ages they have successfully concealed themselves from their feathered enemies owing to the resemblance between their plumage and their surroundings. Of this the common ptarmigans afford a striking instance. Living on the bare mountain tops, where they have no means of concealment from birds of prey, their plumage changes with the seasons, the pure white garb which they assume in winter rendering it difficult to distinguish them from the snow which clothes the hills. In the spring and summer their upper parts become grayish drab, which is equally effective in protecting them from birds of prey.

The gradual assumption of sober-colored plumage by defenseless birds has led to a corresponding increase in the cunning of their feathered foes. Thus we often see a hawk or falcon sitting on a branch motionless close to the trunk of a tree, its plumage harmonizing with the bark to such an extent that the bird is scarcely visible till it shifts its position, or darts with sudden swoop upon some unsuspecting victim. Birds which nest in company, such as some gulls and rooks, take little trouble to conceal themselves or their eggs. Their numbers serve to give them confidence, and a hawk approaching the nests would meet with a rough reception. It is, as a rule, the shy and timid species which have no other adequate means of protection that have been aided by Nature to conceal themselves, their nests, and their young.

* Country Life (London).

CENTRIFUGAL FILTRATION OF SEWAGE SLUDGE.

THE problem attending the desiccation of sewage sludge has undergone considerable simplification and cheapening as the result of a new system that has been devised by an English doctor, and practical demonstrations with which were recently carried out. The general system now in vogue of treating the sludge in sewage-settling tanks is its passage through filtering presses. As the raw sediment contains approximately 90 per cent of water, the elimination of this liquid is no easy matter. The filtering presses are operated on the average at a pressure of 60 pounds per square inch, and the result is the extraction of about 88 per cent of the original bulk of water present in the sludge. Despite the simple character of such a pressing system, however, the cost is unduly heavy, averaging from 50 cents to $1.25 per ton, as invariably the sediment is of such a slimy nature that the addition of certain chemicals or lime is necessary in order to secure some consolidation of the mass to facilitate pressing. Even then great trouble is experienced with the pores of the pressure cloth, which become clogged, requiring frequent cleansing or renewal.

By the new system, however, the use of lime or other chemicals exercising a binding tendency upon the sludge is dispensed with, as is also the press with its attendant straining cloths. Instead, desiccation is effected purely by a new method of applying the principles of centrifugal force, one of the most important features of which is that the viscous properties of the raw settlement are of assistance rather than a hindrance. A partially-covered cylinder set in a vertical position is rotated at a very high speed. The result of the centrifugal action thus set up is that the heavier solid particles of the sludge, acquiring a greater momentum than the liquid portion, are hurled against the sides of the vessel, leaving the central space occupied by the liquid. Consequently, after the cylinder has been revolved for a short while, there are two separately revolving masses within—the solid particles near the walls and the free liquid in the center. In this manner complete separation of the fluid and solid constituents of the sludge is secured. At first it may not be apparent how the viscous character of the sludge is of material assistance to the process, but this may readily be seen when the machine is in operation. When the speed of rotation is stopped or slackened, the slimy particles adhere to the w[illegible] of

the vessel in the form of a dense cake, while the water falls to the bottom in the center and can easily be drawn off, the solid mass adhering to the inner surface of the wall carrying an insignificant proportion of water.

As is well known, the proportion of pressure that can be brought to bear upon such a substance as sewage sludge is dependent upon the diameter of the cylinder, weight of the mass, and speed of rotation. With a vessel of 6 feet diameter, quite a moderate speed is sufficient to secure a pressure of 60 pounds per square inch, with a drive of less than 10 horsepower, yielding a production of about half a ton of desiccated sewage per hour. As the inventor demonstrated before a body of technical men and engineers in Manchester, the cost of production averages about 25 cents per ton, representing a saving of from 75 to 80 per cent as compared with the ordinary pressure filter system. This is an important consideration to those towns where after filtering the sediment is carried out to sea and dumped, since it would enable the hoppers to handle four times as much solid sewage as is now the case.

Moreover, the apparatus and system is applicable to other industries with equally economical results, such as peat, potters' clays, chemical products of various descriptions which in their raw state possess viscous properties. The practical demonstration carried out showed that with this machine a solid cake of high density can be produced from liquid sewage in the course of a few minutes, and the water subsequently drawn off was found to be practically free from solids. The system is to be tried on a practical scale at the sewage works of a north of England town, and its operation will be followed very closely by all engineers concerned with the question of sewage disposal.

SCIENCE NOTES.

An economical development in the Queensland dairy industry has been effected by the perfection of a process for the manufacture out of straw of the boxes in which the butter is packed for shipment. Hitherto such boxes have been made of pine-wood; but owing to the extensive expansion of the butter-export trade, and a coincident heavy demand for the necessary wood (the forests of which are being rapidly depleted), the latter has reached a prohibitive figure. Over three million boxes, representing a cost of something like two hundred thousand pounds, are now used every year in Australia in this trade alone. The new box, which costs only a few pence, is made of straw and kaolin, and by its use farmers, it is estimated, will effect a saving of nearly fifty thousand pounds per annum. The box is strong, odorless, and damp-proof, and compares very favorably in weight with the wooden article.

Every ton of coal which is burned uses up 300,000 cubic feet of air and renders it unfit for breathing. Suppose that there were no danger of exhausting our coal supply, and that we had enough to last forever; it would only be a few hundred years at our present rate of increase in coal consumption, and incidentally oxygen consumption, until all the atmosphere on the earth's surface would be rendered incapable of sustaining life. However, as has been called to our attention by Prof. Arrhenius, the consumption of coal at present is returning to the atmosphere the carbon dioxide of which it was robbed when the deposits of carbon were stored away in the coal beds during the carboniferous period. The present proportion of carbon dioxide in the air is about one part in 2,500. This would be more than doubled by the consumption of the present known coal deposits, and it is stated that a doubling of the quantity in the atmosphere would more than double the rate of growth of plant life.

It is a somewhat regretable circumstance that the pea, which is one of the most nutritious articles of food, does not meet with a greater measure of popularity. From the proteid standpoint it is much superior to oatmeal, being some 80 per cent richer in this substance than the latter, with a high percentage of carbohydrates and a small proportion of water. In fact, the pea is an ideal edible, since it possesses practically the whole of the constituents in correct proportions for the building up of animal tissue. No doubt during the summer season peas are extensively eaten, though it is to be feared they are regarded more as a tasty pseudo-epicurean dish than as a staple article of food. But it is during the winter that their advantages can be more strikingly secured. During the past few years inventive effort has succeeded in devising satisfactory means of preserving the results of summer cultivation in an appetizing form without any recourse to pernicious coloring or preservative mediums. Formerly, out-of-season peas were either stored in bottles or tins in conjunction with deleterious conserving fluids, the dangerous character of which was betrayed by the vivid verdant hue of the contents; or they were sold in a dry form, packed in sacks, which certainly presented an uninviting appearance. Such antiquated methods have, however, now given way to hygienic and more attractive means of supplying the market. The peas, carefully selected, graded, and dried, are now packed in air-tight cardboxes in which they well retain their qualities for a considerable time, and when properly cooked yield a dish in every way as alluring to the palate as those freshly garnered from the field or garden in the height of the season.

ENGINEERING NOTES.

The Roosevelt dam now being built by the United States Reclamation Service on Salt River, Arizona, when completed, will be far the largest artificial lake in the world. It will impound 1,300,000 acre-feet of water, and will thus hold the record until the completion of the Engle dam. At present an Indian reservoir, which is filled only once in about twenty years, is the largest, with a capacity of 950,000 acre-feet.

Probably the oldest derricks still in use are the two built at Trier in Germany in the year 1413, and the one built in 1554 at Andernach, also in Germany. All these three derricks are built on the same principle. In the middle of a massive A-frame tower is located the swinging or main boom, 20 x 20 inches, whose iron pivot moves in a pan-shaped bearing cup. On top are fastened the guy ropes and the cap, which is also movable. The derrick can be moved by cross bars fastened to the main boom. The load is chain-lifted by treadwheels 16 feet in diameter.

A British publication states that a new syndicate has established a factory in London and is placing upon the market a new form of leather, for which it is claimed there is a big fortune, and which it thus describes: The leather is submitted to a tanning process of the chrome variety, which preserves it; rubber solution is then worked into the interstices, rendering the hide thoroughly waterproof. The elasticity of the rubber permits of perfect flexibility and extraordinary toughness of some of the skins, especially of rabbit, goat, and sheep skins. It is impossible to forecast the many uses for which this process may be available. Tests have been made for motor tires, soles for boots and shoes, pump washers, machine belting, miners' boots, etc., and it is probable that the multitude of articles that can be made of rubberized leather will, in time, create a further demand for rubber. This new material, it is thought, may also prove useful for motor and cycle tires, as it is almost impossible to puncture it, while it is said to be much more resilient and waterproof than ordinary leather.

The use of hydrofluoric acid in pickling castings is coming into use and is in some respects superior to sulphuric and hydrochloric acids. The latter attack the metals. Before pickling in the fluoric acid it is desirable, of course, that the castings be brushed clean and all fins and cores removed. The solution of acid and water is effective in a ratio of 1 to 10, but as the pickling bath becomes weakened, a supply of fresh acid is necessary to maintain the strength of the pickle. It is noted that the sand is speedily loosened from the castings by the action of the acid and that the silica in the metal is also attacked so that the machining of the casting is rendered very easy. It is also noted that in painting castings that have been treated by fluoric acids the paint is much more enduring than when applied to the surface of unpickled castings. The cost is much less than in the use of sulphuric acid, about 10 cents per gallon being about the average price of the pickle, sufficiently strong for ordinary use. Fluorine gas, from which this acid is made, is the principal reagent used in etching upon glass, as its affinity for sand is very great. Hydrofluoric acid takes the sand off castings very quickly.—Railroad and Locomotive Engineering.

The question of power required for rolling has always been enshrouded in a veil of secrecy; rolling mill men have been loath to impart information acquired by experience. In designing rolling-mill engines, Prof. Trinks found that lack of this knowledge was general. As a specific case, take an engine to drive an 18-inch mill. The material to be rolled may be soft iron or hard steel—one requiring nearly twice the power of the other—and may enter the rolls very hot, or rather cold; the draft of the rolls may be light or heavy, and there may be material in only one pass or in two or three at a time. All this makes variations of over 300 per cent in maximum power required. All this is not considered by the mill man, who merely specifies "an engine for an 18-inch mill." About all that can be done is to take the worst possible case and build an engine that will not be stalled even though the material gets so cold that the rolls or housings are broken. We should have more information on this subject and much credit is due the electrical engineers for their thorough experiments and investigations on similar steam direct-driven mills by means of the continuous indicator. We owe much to the liberal policy of large electrical companies for data published broadcast, and which forms the only reliable information published on the subject.

TRADE NOTES AND FORMULÆ.

Holland Compound is a solution of 5 parts of so water glass and 1 part of carbonate of soda, or powder mixture consisting of 3 parts of calcined so and 1 part of dry potash water glass. Ten parts this mixture is said to be sufficient to render 100,0 parts of hard water soft.

Lubrication for Glass Faucets is provided by mi ing 70 parts of pure caoutchouc and 30 parts of ye low, unbleached beeswax. The caoutchouc is melte in a covered vessel and the beeswax added. This lubr cant is even proof against concentrated caustic alk lies and in thin layers is translucent. At the sam time, it can easily be removed from the glass, bein attacked and loosened by means of a little conce trated nitric acid and then washed off with water.

Preservation of Wood.—For this purpose melte naphthaline may be used, which is placed in a ves in which the wood is immersed. The temperature the bath is 194 deg. F. or somewhat lower and shou be kept at a uniform height. For this purpose t heating is effected by steam pipes passing through t reservoir. The wood, according to its size, remai from 9 to 12 hours in the bath, during which peri the naphthaline comes to occupy the place of the in the wood. Wood carefully impregnated in this ma ner is said to possess increased capacity for takin polish, a simple rubbing with a cloth being sufficie

New Process of Refining Gum Arabic.—20 pounds the impure gum Arabic are inclosed in a sack of ver coarse texture which is suspended in a tin plate cyli der in such a manner that the bottom of the bag do not extend beyond the middle of the height of th cylinder. The cylinder is best made twice as hig as wide. In the cylinder we now introduce about quarts of water, which is allowed to stand. Witht 24 hours, everything is dissolved, provided the sac is completely submerged in the water. In the sac we now have the undissolved wood together with th earth and dirt and in the cylinder an almost clea solution of gum, of about 12 deg. Bé. The gum sol tion is run into about 50 quarts of alcohol, strong acidified with hydrochloric acid, stirred up and allowe to stand and settle. We then have as a snow whit deposit the chemically pure arabic acid, whereas th bases, especially the iron, remain in solution in th acid alcohol. The spirit is decanted, neutralized wit caustic lime and passed through a still to effect i recovery. The deposit of arabic acid is transferre to tin plates and dried in the drying chamber. Th gum thus obtained is almost limpid and is a ver good adhesive.

Castings of Chloride of Zinc.—By mixing a concen trated solution of chloride of zinc, which must be at least 55 deg. Bé., with highly heated zinc oxide, w obtain a mass that is admirably adapted for the cas ing of various art objects; it is at least equal in hard ness to marble and takes a high polish; as regard its behavior to exterior influence, it excels marbl altogether in its power of resistance, being unaffecte by the action of severe cold, moisture or even boilin water, and it is also fairly indifferent to the effect of very strong acids. This casting mass is best pre duced by taking 2 parts of zinc white which ha been highly heated (calcined), and after cooling, kep in air-tight glass vessels until needed, and mixin it with 1 part of chloride of zinc solution of 55 deg Bé. To effect the mixture, we use a porcelain vesse in which we place first the zinc oxide, then pour i the chloride of zinc solution and, by stirring with flat spatula, produce a uniform mixture. In mixing great care must be taken that no air bubbles occu in the mass, for these would give rise to defectiv castings. The well-stirred mixture is allowed to stan until it begins to become more fluid, and it is the poured into molds in which it is permitted to harde If the zinc oxide, before use, is mixed with groun glass or with colors that exercise no chemical effe on zinc oxide (English red, manganese, chrome gree red lead), colored castings can be produced.

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